

T. Stothard del. J. Basire sculp.

What magnificent ideas of the Creator and his works does the starry firmament present!

No. 7.

Published August 25, 1800, by W. Bent.



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THE

CONTEMPLATIVE PHILOSOPHER:

OR

SHORT ESSAYS

ON THE

VARIOUS OBJECTS OF NATURE

THROUGHOUT THE YEAR;

WITH

POETICAL ILLUSTRATIONS AND MORAL REFLECTIONS ON EACH SUBJECT.

IN TWO VOLUMES.

VOL. I.

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ADVERTISEMENT.

THESE Eſſays appeared originally in the UNIVERSAL MAGAZINE, between the years 1785 and 1792, the ſubject of each paper ſuitable to the month in which it was inſerted. They were highly approved at that time, not only as amuſing and inſtructive philoſophical diſquiſitions, but alſo for the poetical illuſtrations and moral reflections introduced in them. Much inquiry and repeated ſolicitations having been made after the CONTEMPLATIVE PHILOSOPHER, as a ſeparate work, it now appears in the preſent form; the Eſſays being carefully reviſed, and arranged as the ſubjects of them naturally occur in the courſe of the year.


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THE

CONTEMPLATIVE PHILOSOPHER.

NUMBER I.

REFLECTIONS ON WINTER.

Vides, ut alta ſtet nive candidum
Soracte, nec jam ſuſtineant onus
Sylvæ laborantes, geluque
Flumina conſtiterint acuto. HORACE.

Behold yon mountain's hoary height
Made higher with new mounts of ſnow;
Again, behold the winter's weight
Oppreſs the lab'ring woods below:
And ſtreams, with icy fetters bound,
Benumb'd and crampt as ſolid ground. DRYDEN.

WHEN Nature, in a ſtate of deſolation, ſeems, to an inattentive eye, to preſent nothing, as it were, but the creation in diſtreſs, the Contemplative Philoſopher, as he walks forth to explore the dreary ſcenes around him, will diſcover a great variety of phenomenons peculiar to this ſeaſon, with ſufficient beauty or uſefulneſs in each to merit a diſtinct diſcuſſion. Whether he contemplates Winter in its firſt approaches, or enters into a minute inveſtigation of its various ſcenery; whether he confines his

reſearches to our temperate zone, or makes excurſions to the polar regions; each ſubject, ſeparately conſidered, will afford ample room for poetical illuſtration and philoſophical inquiry.

Of all the poets, ancient or modern, Thomſon has exhibited the nobleſt group of winter imagery. Nor is this to be wondered at in a poet, who, in his earlieſt years, was fond to view Nature, not only in her beautiful and ſmiling aſpects, but, like the great Salvator Roſa, in the frowning, the terrific, and ſublime. This he intimates himſelf, at the opening of his poem, in which he introduces Winter approaching with all the gloomy pomp of perſonification:

See, Winter comes, to rule the varied year,
Sullen and ſad, with all his riſing train:
Vapours, and clouds, and ſtorms. Be theſe my theme,
Theſe! which exalt the ſoul to ſolemn thought,
And heavenly muſing. Welcome, kindred glooms!
Congenial horrors, hail! With frequent foot,
Pleas'd have I, in my cheerful morn of life,
When nurs'd by careleſs Solitude I liv'd,
And ſung of Nature with unceaſing joy,
Pleas'd have I wander'd thro' your rough domain;
Trod the pure virgin-ſnows, myſelf as pure;
Heard the winds roar, and the big torrents burſt;
Or ſeen the deep fermenting tempeſt brew'd,
In the grim evening ſky.

Contemplations of this kind were indeed ſuited to the ſerious and virtuous ſoul of Thomſon. They raiſed to nobler heights the fire of poetry and the ardour of devotion; and the winds, and ſtorms, and torrents, led him to exclaim,

Nature! great parent! whoſe unceaſing hand
Rolls round the ſeaſons of the changeful year,
How mighty, how majeſtic are thy works!
With what a pleaſing dread they ſwell the ſoul!
That ſees aſtoniſh'd [illegible] aſtoniſh'd ſings!



Virgil, in a fine ſpecimen of that variety, that magic art which conſtitutes one of the greateſt beauties of poetry, ſuddenly conveys his reader from the paſtoral ſcenes of Africa to the pictureſque horrors of a Scythian winter [a]. Thomſon's view of Winter in the polar circle is a noble imitation of this deſcription; but he ſoars far beyond his maſter, over deſerts of ſnow, and oceans of ice, to the pole itſelf. Here again he perſonifies Winter, and enthrones him in dreadful ſolitude and magnificent deſolation.

Still preſſing on beyond Tornea's lake,
And Hecla flaming thro' a waſte of ſnow,
And furtheſt Greenland, to the pole itſelf,
Where, failing gradual, life at length goes out,
The Muſe expands her ſolitary flight;
And, hov'ring o'er the wide ſtupendous ſcene,
Beholds new ſcenes beneath another ſky [b].
Thron'd in his palace of cerulean ice,
Here Winter holds his unrejoicing court,
And through his airy hall the loud miſrule
Of driving tempeſt is for ever heard:
Here the grim tyrant meditates his wrath;
Here arms his winds with all-ſubduing froſt;
Moulds his fierce hail, and treaſures up his ſnows,
With which he now oppreſſes half the globe.

In a general view of winter, in this country, I ſhall not attempt to give a philoſophical account of the various phenomenons peculiar to this inclement ſeaſon; nor ſhall I purſue my reſearches, at preſent, into more northern regions.—Winter has been defined to be that ſeaſon of the year in which the days are ſhorteſt. It moſt properly commences on the 21ſt of December, which is called the Winter Solſtice, being that day when the ſun's diſtance from the zenith of the place is the greateſt; and it ends on

[a] Quid tibi paſtores Lybiæ, &c. GEORG. III. 319.
[b] The other hemiſphere.

the 20th of March, when its diſtance is at a mean between the greateſt and the leaſt. But I ſhall only obſerve further, that notwithſtanding the coldneſs of this ſeaſon, it has been demonſtrated by aſtronomers, that the ſun is really nearer to the earth in winter than in ſummer. The principal cauſe of this difference is, that in winter the ſun's rays fall ſo obliquely upon us, and have ſo large a portion of the atmoſphere to paſs through, that any given number of them is ſpread over a much greater portion of the earth's ſurface where we live; and therefore each point muſt then have fewer rays than in ſummer, or when the ſun is at a greater height above the horizon. There comes, moreover, a greater degree of cold in the long winter nights, than can be compenſated for by the return of heat in the ſhort days; and, on both theſe accounts, the cold muſt neceſſarily increaſe. In ſummer, on the contrary, the rays of the ſun fall more perpendicularly upon us, and therefore come with greater force, and in greater numbers on the ſame place, than when they come more obliquely; and, by the longer continuance of the ſun above the horizon than in winter, a much greater degree of heat is imparted by day than can fly off by night, ſo that the heat muſt increaſe.

Severe and rigorous as winter is deſcribed to be, its various ſcenes, however, cannot fail to ſuggeſt many ſubjects of gratitude to the Contemplative Philoſopher. Few minds are ſo devoid of ſenſibility, as not to experience the moſt grateful emotions, when the inexhauſtible bounties of the Supreme Being bloom around in ſpring, in beautiful profuſion; delight the eye in ſummer, with maturing promiſe; and ripen, in autumn, into rich and exquiſite perfection. In general, even in minds not unſuſceptible in other reſpects, we ſeldom find a diſpoſition to grateful admiration, when they behold the ravages in the creation; the orchards ſtript of their golden

fruits; and harmony extinct in the groves, now bending with the ſnow, "their beauty wither'd, and their verdure loſt".

No mark of vegetable life is ſeen,
No bird to bird repeats his tuneful call,
Save the dark leaves of ſome rude evergreen,
Save the lone redbreaſt on the moſs-grown wall.
SCOTT.

But the benign Governor of the univerſe, who has ſubjected his creatures to the rigours of this ſeaſon, has graciouſly enabled them to mitigate its ſeverity by a variety of reſources. The woods, which, in ſpring, crowned the hills with majeſtic verdure, now contribute to erect the comfortable manſion; or, added to what is extracted from the bowels of the earth, afford us the unſpeakable bleſſing of fire. The flocks, which no longer gladden our plains, nor, to the poetic eye, revive Arcadian ſcenes, have given us their ſummer fleeces to protect us from the piercing cold; and the fruits with which autumn adorned our orchards, are now laid up, with its golden harveſts, for our nouriſhment and ſupport. In a word, the devout mind may have reaſon, even in winter, to exclaim with the Pſalmiſt, "O Lord, how manifold are thy works! In wiſdom haſt thou made them all: the earth is full of thy riches".

Had it been given to us mortals to comprehend the connection of every thing in nature, with what fervour of admiration ſhould we adore the wiſdom and goodneſs of the great Creator! But although we are incapable of forming an idea of the plan and extent of his wondrous works (thoſe works which diſplay infinity in the two extremes of magnitude and minuteneſs) we may yet perceive enough to convince us, that, with reſpect to the happineſs of the whole, every thing in nature muſt be ultimately ordered for the beſt. Winter belongs not leſs to

the divine plan than the more pleaſing ſeaſons of the year. Were there no winter, neither the ſpring, nor ſummer, nor autumn, would diſplay ſuch a variety of beauties; for the earth itſelf would loſe thoſe rich ſtores of nouriſhment and fertility, to which even the winter ſo copiouſly contributes.

The felicities of the golden age are beautiful in poetic viſion. A youthful fancy is delighted with fruits and bloſſoms bluſhing, "in ſocial ſweetneſs, on the ſelf-ſame bough". It wanders with ecſtaſy, through groves adorned with perennial verdure, while Favonian gales perfume the ever-ſmiling ſkies. But theſe are the enchanted reveries of fiction, not the ſober repreſentations of truth. The human mind, which ſeems ever anxious for new gratifications, would revolt at the idea of perpetual ſameneſs and uniformity, even in the moſt beautiful ſcenes and the moſt exquiſite enjoyments. One can have no idea of happineſs, when it does not, in ſome degree, reſult from compariſon: for not only variety contributes much to our ſenſe of happineſs, but not unfrequently a recollection of former calamities, or of ſome recent ſuffering. That degree of eaſe which we ſcarce regard in the full enjoyment of health, is ecſtaſy itſelf, when pain has taught us how to prize the ineſtimable bleſſing. In the moral world "how ſweet are the uſes of adverſity", which beſt inſtruct us how to eſtimate and how to enjoy proſperity. In like manner, the recollection of the frowning ſkies of winter will make us rejoice in the return of that ſpring, in whoſe flowery walks, if perpetual, we ſhould have trod with languor and indifference. More cheerily will the heart then dance to the muſic of the groves, when it recollects how recently their tuneful haunts were dumb. Brighter then will be the verdant robes which the woods aſſume, contraſted to their late leafleſs and inhoſpitable appearance; and, as "hope waits upon the flowery prime", the

fruits and flowers, when they bud, will delight the fancy, in ſweet anticipation, with all the pride of ſummer, and all the riches of autumn. The rigours of departed winter will be forgotten in that all-enlivening renovation of Nature. In a word, our hearts, then attuned to cheerfulneſs and gayety, will confeſs this important truth, that, "as Providence has made the human ſoul an active being, always impatient for novelty, and ſtruggling for ſomething yet unenjoyed with unwearied progreſſion, the world ſeems to have been eminently adapted to this diſpoſition of the mind: it is formed to raiſe expectation by conſtant viciſſitudes, and to obviate ſatiety by perpetual change".

II. ON WINDS AND STORMS.

Ingeminant auſtri, et denſiſſimus imber:
Nunc nemora ingenti vento, nunc litora plangit.

VIRGIL.

The winds redouble, and the rains augment:
The waves on heaps are daſh'd againſt the ſhore,
And now the woods, and now the billows roar.

DRYDEN.

AS Winter unfolds his awful train, "vapours, and clouds, and ſtorms", the Contemplative Philoſopher becomes habituated to views of the ſtupendous and ſublime. Verdant groves, variegated meadows, and radiant ſkies, are now ſucceeded by leafleſs woods, dejected waſtes, and a frowning atmoſphere. But while the incurious and inattentive mind perceives a dreary uniformity in all around, the penetrating eye of the rural ſtudent diſcovers many a varied aſpect of beauty and excellence, which ſtill

invite to the moſt pleaſing inveſtigation. And, however paradoxical it may appear, he finds inexhauſtible ſources of ſerenity and delight, in that mood of melancholy muſing on ſcenes of deſolation, which, in vulgar eſtimation, would rather

Deepen the murmur of the falling floods,
And breathe a browner horror o'er the woods. POPE.

In fine, in each viciſſitude of the ſeaſons, he ſtill diſcerns the omnipotent Creator, ever bountiful to man; and, whether the gentle gales breathe propitious in ſpring, or reſiſtleſs ſtorms ravage the earth in winter, his cultivated mind kindles with devotion, and even calls upon the inanimate world to join him in adoration:

To Him, ye vocal gales,
Breathe ſoft, whoſe ſpirit in your freſhneſs breathes:
Oh, talk of Him in ſolitary glooms!
Where, o'er the rock, the ſcarcely waving pine
Fills the brown ſhade with a religious awe.
And ye, whoſe bolder note is heard afar,
Who ſhake the aſtoniſh'd world, lift high to Heav'n
Th' impetuous ſong, and ſay from whom you rage.
THOMSON.

In the ſubject of my preceding eſſay, I had a ſatisfaction in exhibiting ſome of thoſe admirable pictures, which the great poets and painters of Nature have been fond to trace. I next entered, with the natural philoſopher, into a diſquiſition concerning thoſe wonderful veſtiges of beauty and uſefulneſs, of wiſdom and contrivance, which not only demonſtrate a Creating Hand, but demonſtrate that Hand to be Divine. And finally, with the religious and ſentimental reader, I indulged ſuch moral reflections as the ſubject had a tendency to inſpire. This is the order, which, once for all, I mean to purſue in my future lucubrations, and by which I hope to gratify alike the poet, the philoſopher, and the chriſtian.

The ſubject, hitherto, has been chiefly confined to what the ſurrounding country affords; but we are now carried to the diſtant ocean,

Wide o'er the moving wilderneſs of waves,
From pole to pole through boundleſs ſpace diffus'd,
Magnificently dreadful! MALLET.

Virgil, in the firſt book of his Æneid, gives the deſcription of a ſtorm, which, as Mr. Spence obſerves, probably ſet all the Roman poets a ſtorm painting. Thomſon alſo gives a minute and pictureſque deſcription, with circumſtances more natural to the Engliſh reader, eſpecially in the various preſages that announce the approaching tempeſt[a].

To account philoſophically for the cauſe of winds, we muſt have recourſe to the elaſticity of the air, that property which renders it capable of compreſſion and expanſion. This elaſticity is increaſed by heat, which rarefies and expands the air; and of this property, the wind is a neceſſary conſequence: for, when the atmoſphere is heated over one part of the earth more than over another, the warmer air, in this caſe, being rarefied, becomes ſpecifically lighter than the reſt. It is therefore overpoiſed by it, and raiſed upward; the upper parts of it diffuſing themſelves every way over the top of the atmoſphere; while the neighbouring inferior air ruſhes in from all parts at the bottom; which it continues to do, till the equilibrium is reſtored. Upon this principle it is that moſt of the winds may be accounted for. Hence, moreover, we may account for the ruſhing of the air into a glaſshouſe, or toward any place where a great fire is made; for the aſcending of ſmoke up a chimney; and for a circumſtance ſo little attended to, as the ruſhing of the air through the keyhole of a door, or any ſmall

[a] See his Winter, line 118 to 201.

chink, when there is a fire in the room. Nor is this mere ſpeculation, or conjecture: for the truth of this general obſervation, that the air will preſs toward that part of the world where it is moſt heated, has been demonſtrated beyond any kind of doubt, by the following very ſimple experiment. Fill a large diſh with cold water: into the middle of this put a water-plate filled with warm water. The firſt will repreſent the ocean, and the other an iſland rarefying the air about it. Blow out a wax candle, and if the place be ſtill, on applying it ſucceſſively to every ſide of the diſh, the ſmoke will be ſeen to move toward the plate. Again, if the ambient water be warmed, and the plate filled with cold water, let the ſmoking wick of the candle be held over the plate, and the very reverſe will happen.

Under the equator, the wind is always obſerved to blow from the eaſt point. For, ſuppoſing the ſun to continue vertical over ſome one place, the air will be moſt rarefied there; and conſequently, the neighbouring air will ruſh in from every quarter with equal force. But, as the ſun is continually ſhifting to the weſtward, the part where the air is moſt rarefied, is carried the ſame way; and therefore the tendency of all the lower air, taken together, is greater that way, than any other. Thus the tendency of the air toward the weſt, becomes general; and its parts impelling one another, and continuing to move till the next return of the ſun, ſo much of its motion as was loſt by his abſence, is again reſtored; and therefore the eaſterly wind becomes perpetual.

On each ſide of the equator, to about the 30th degree of latitude, the wind is found to vary from the eaſt point, ſo as to become northeaſt on the northern ſide, and ſoutheaſt on the ſouthern. The reaſon of this is, that, as the equatorial parts are hotter than any other, both the northern and ſouthern

air ought to have a tendency that way; the northern current, therefore, meeting in this paſſage with the eaſtern, produces a northeaſt wind on that ſide; as the ſouthern current joining with the ſame, on the other ſide of the equator, forms a ſoutheaſt wind there.

This is to be underſtood of open ſeas, and of ſuch parts of them as are diſtant from the land; for near the ſhores, where the neighbouring air is much rarefied, by the reflection of the ſun's heat from the land, it frequently happens otherwiſe; particularly on the coaſt of Guinea, where the wind always ſets in upon the land, blowing weſterly inſtead of eaſterly. This is occaſioned by the deſerts of Africa, which lying near the equator, and being a very ſandy ſoil, reflect a greater degree of heat into the air above them; which being thus rendered lighter than the air which is over the ſea, the wind continually ruſhes in upon the land, to reſtore the equilibrium.

That part of the ocean which is called the Rains, is attended with perpetual calms, the wind ſcarcely blowing ſenſibly either one way or the other. For this tract being placed between the weſterly wind blowing from the ocean toward the coaſt of Guinea, and the eaſterly wind blowing from the ſame coaſt to the weſtward thereof, the air ſtands in equilibrium between both; and its gravity is ſo much diminiſhed thereby, that it is not able to ſupport the vapour it contains, but lets it fall in continual rain; and hence this part of the ocean receives its name.

There is a ſpecies of winds, obſervable in ſome places between the tropics, called Monſoons, or Trade Winds, which, during ſix months of the year, blow one way, and the remaining ſix the contrary. The cauſe of them, in general, is this: when the ſun approaches the northern tropic, there are ſeveral countries, as Arabia, Perſia, India, &c. which become hotter, and reflect more heat than the

ſeas beyond the equator, which the ſun has left; the winds, therefore, inſtead of blowing thence to the parts under the equator, blow the contrary way; and when the ſun leaves thoſe countries, and d aws near the other tropic, the winds turn about, and blow on the oppoſite point of the compaſs.

From the ſolution of the general trade winds, we may ſee the reaſon, why in the Atlantic ocean, a little on this ſide the 30th degree of north latitude, there is generally a weſt or ſouthweſt wind. For, as the inferior air, within the limits of thoſe winds, is conſtantly ruſhing toward the equator, from the northeaſt point, or nearly ſo, the ſuperior air moves the contrary way; and, therefore, after it has reached theſe limits, and meets with air, that has little or no tendency to any one point more than to another, it will determine this air to move in the ſame direction with itſelf.

In our own climate we frequently experience, in calm weather, gentle breezes blowing from the ſea to the land, in the heat of the day; which phenomenon is very agreeable to the principle laid down above: for the inferior air over the land being rarefied by the beams of the ſun reflected from its ſurface, more than that which impends over the water, the latter is conſtantly moving on to the ſhore, in order to reſtore the equilibrium, when not diſturbed by ſtronger winds from another quarter. And hence, in hot countries, the ſea breezes almoſt invariably blow from ſea to land, in the daytime; and the land breezes, on the contrary, in the night.

From what has been obſerved, nothing is more eaſy than to ſee, why the northern and ſouthern parts of the world, beyond the limits of the trade winds, are ſubject to ſuch variety of winds. For the air, on account of the ſmaller influence of the ſun in thoſe parts, being undetermined to move toward any fixed point, is continually ſhifting from

place to place, in order to reſtore the equilibrium, wherever it is deſtroyed; whether by the heat of the ſun; the riſing of vapours or exhalations; the falling of great quantities of rain, or the melting of the ſnow upon the mountains, which each cauſes a ſudden condenſation or compreſſion of the air; or by high mountains, which alter the direction of the winds. For to theſe, not to mention other circumſtances, we may trace the origin of all thoſe ſtorms, hurricanes, whirlwinds, and irregularities, which happen at different times and places.

From this account of the nature and cauſes of the winds, it is natural to advert to their various uſes in the material world. And here the ſuperficial obſerver may inquire, how it happens, that with ſuch evident marks of wiſdom and contrivance in the objects we have hitherto ſurveyed, a Being infinitely good, as well as wiſe and powerful, could permit ſuch a variety of evils as are produced by ſtorms and tempeſts; by which whole countries have been ravaged, and thouſands in every age overwhelmed in the ocean. To this it may be obſerved, that nothing is properly an *evil*, which it is conſiſtent with the perfections of the Deity to permit or appoint, but what deſerves that character *upon the whole*. This we can never preſume to ſay of any thing that we are acquainted with, nor, indeed, of any natural evils that are of a limited duration. It is more becoming to ſuppoſe, that they may have a tendency to promote the more ſolid and permanent happineſs of *individuals* (after ſeveral intermediate conſequences, which we are too ſhortſighted to trace) as well as the *general good* of the creation. Nor can we demonſtrate, or even argue the contrary with any probability, unleſs we can likewiſe comprehend all the infinite variety of deſigns, that an all-wiſe Being may intend to effect by particular occurrences, and thoroughly underſtand the whole plan of his go-

vernment, the connection of the ſeveral parts of it, and their reference and ſubordination to each other.

'Tis but a part we ſee, and not a whole. POPE.

It muſt, at leaſt, be unqueſtionable, that what ſeems wrong in the preſent ſtate, may be amply rectified in ſome future ſcene of exiſtence, and the preſent evil infinitely overbalanced by the ſucceeding good.

It may further be obſerved, with the poetical philoſopher juſt quoted, that "all partial evil is univerſal good". Of what we call natural evils, many are moſt admirably adapted to the preſervation and welfare of the creation.

In thy world material, mighty mind!
Not that alone which ſolaces and ſhines,
The rough and gloomy, challenges our praiſe.
The winter is as needful as the ſpring;
The thunder as the ſun: a ſtagnant maſs
Of vapours breeds a peſtilential air:
Not more propitious the Favonian breeze
To Nature's health, than purifying ſtorms. YOUNG.

In a word, the more attentively we conſider this ſubject, the Contemplative Philoſopher cannot but learn this important truth, that from the natural evils, incident to the preſent frame and conſtitution of things, the Divine Being is either conſtantly educing good, or will finally render them ſubſervient, on the whole, to the happineſs of his creatures. Nor can a benevolent mind derive a nobler conſolation in calamity, than from the conſideration, that the immediate cauſe of his ſufferings may, perhaps, in the providential courſe of events, be conformable to ſome gracious intention in that Being, who is the inexhauſtible fountain of good to all his creatures; and that not only the winds, in general, are productive of various benefits to mankind, but that the very ſtorm, which perhaps ravaged his

lands, or plunged ſome loved relation in the deep, was neceſſary to ventilate the ſkies, to agitate the ocean into wholeſome rage, and to ſweep from the earth thoſe noxious vapours, which, if permitted to be at reſt, would be productive of all the fatal effects of infection and diſeaſe. And with reſpect to himſelf, as an individual, he will rejoice in the reflection, that after a few years more, ſpent in the aſpiring hopes of faith and piety[a], the benevolent exertions of virtue and goodneſs, and the patient exerciſe of fortitude and reſignation, all the momentary evils of this life will be ſucceeded by unfading peace and everlaſting joy:

The ſtorms of wintry life will quickly paſs,
And one unbounded ſpring encircle all. THOMSON.

III. ON SNOW.

Why hover ſnows, and wanton in the air,
Fall by degrees, and clothe the hoary year?
BROOME.

He gives the winter's ſnow her airy birth,
And bids her virgin fleeces clothe the earth.
SANDYS.

AMONG the various phenomenons of winter, not one is more worthy of diſcuſſion than that of Snow, which is confeſſedly one of the moſt curious productions of Nature, and, in the remoteſt ages of antiquity, has excited the admiration of the poets and philoſophers, whether ſacred or profane. The author of the book of Job, in the diſcourſe which he puts into the mouth of Elihu, concerning the glo-

[a] Hope humbly then; with trembling pinions ſoar;
Wait the great teacher Death; and God adore. POPE.

rious and incomprehenſible works of the Deity, thus expreſſes himſelf: "God thundereth marvellouſly with his voice: great things doeth he, which we cannot comprehend: for he ſaith to the ſnow, Be thou on the earth".—And he repreſents the omnipotent Jehovah, in his ſublime expoſtulation with the patriarch, thus demanding: "Haſt thou entered into the treaſures of the ſnow, or haſt thou ſeen the treaſures of the hail, which I have reſerved againſt the time of trouble, againſt the day of battle and war"?—"He giveth (ſays the Pſalmiſt) ſnow like wool: he ſcattereth the hoar-froſt like aſhes. He caſteth forth his ice like morſels: who can ſtand againſt his cold"?—"At his commandment (ſays the wiſe Son of Sirach) he maketh the ſnow to fall apace—As birds flying he ſcattereth the ſnow, and the falling down thereof is as the lighting of graſshoppers. The eye marvelleth at the beauty of the whiteneſs thereof, and the heart is aſtoniſhed at the raining of it".

Homer, the venerable ſire of bards, has deſcribed a ſhower of ſnow, and its extenſive effects, in a noble ſtrain of poetry:

In Winter's bleak uncomfortable reign,
A ſnowy inundation hides the plain;
Jove ſtills the winds, and bids the ſkies to ſleep;
Then pours the ſilent tempeſt, thick and deep:
And firſt the mountain tops are cover'd o'er,
Then the green fields, and then the ſandy ſhore;
Bent with the weight the nodding woods are ſeen,
And one bright waſte hides all the works of men:
The circling ſeas alone, abſorbing all,
Drink the diſſolving fleeces as they fall. POPE.

Ariſtotle's definition of ſnow and hail is conciſe and juſt: "Snow is a cloud congealed, and hail congealed water". Pliny calls ſnow "the foam of celeſtial waters when they daſh againſt one another".

This is very ingeniouſly expreſſed for a poet, but it is not the definition of a philoſopher. Lucretius enumerates ſnow among a variety of phenomenons, the cauſes of which, he ſays, it is eaſy to inveſtigate. He is content, however, to leave the ſubject to the ſagacity and reſearches of his readers:

Cætera, quæ ſurſùm creſcunt, ſurſùmque creantur;
Et quæ conſcreſcant in nubibus omnia, prorsùm
Omnia, nix, venti, grando, gelidæque pruinæ,
Et vis magnus geli, magnum duramen aquarum;
Et mora, quæ fluvios paſſim refrenit eunteis;
Perfacile 'ſt tamen hæc reperire, animoque videre
Omnia quo pacto fiant, quareve creentur,
Cum bene cognôris, elementis reddita quæ ſint.

Meteors, that high aſcend th' aerial way,
Or float in clouds, and various forms diſplay;
The ſnow that whitens over all the ground;
The winds that wide ſpread deſolation round;
The rattling hail; and beauteous-fancied froſt,
With hoary charms on every plant emboſt;
The ice, whoſe mighty force pervades the woods,
Binds deep the earth, and ſtops the rapid floods;
Of theſe, how eaſy 'tis to trace the cauſe,
When once you know, when once conceive their laws[a].

But we need not conſult the ancients, either for the beauties of poetical illuſtration, or the acquiſitions of philoſophical inquiry, while we can have recourſe to our own admirable poet of the Seaſons. What can be more minutely circumſtantial, or more elegantly accurate than the following deſcription?

[a] And how the other meteors riſe and fall,
What ſtamps the figur'd ſnow, and moulds the hail,
And why the water's pride and beauty 's loſt,
When rig'rous winter binds the floods with froſt,
'Tis eaſy to conceive, if once we know
The nature of the elements, or how
Their fighting pow'rs muſt work, or what they do.

CREECH.

The keener tempeſts riſe: and, foaming dun
From all the livid eaſt, or piercing north,
Thick clouds aſcend; in whoſe capacious womb
A vapoury deluge lies, to ſnow congeal'd.
Heavy they roll their fleecy world along;
And the ſky ſaddens with the gather'd ſtorm.
Thro' the huſh'd air the whitening ſhower deſcends,
At firſt thin wavering; till at laſt the flakes
Fall broad, and wide, and faſt, dimming the day,
With a continual ſnow. The cheriſh'd fields
Put on their winter robe of pureſt white.
'Tis brightneſs all; ſave where the new ſnow melts
Along the mazy current. Low, the woods
Bow their hoar head; and, ere the languid ſun
Faint from the weſt emits his evening ray,
Earth's univerſal face, deep hid, and chill,
Is one wide dazzling waſte, that buries wide
The works of man.

The limits of this paper will not allow me to proceed to the poet's account of the effects which the inclemency of the ſeaſon has upon animals, and particularly the feathered tribes, while the ſnow is upon the ground; nor to his deſcription of the driving of the ſnows, by which whole flocks of ſheep are ſometimes overwhelmed; nor to his celebrated epiſode of a man periſhing in the ſnow. But in this laſt there is a circumſtance deſcribed, ſo truly original, ſo natural and pathetic, that I cannot forbear to quote it.

In vain for him th' officious wife prepares
The fire fair-blazing, and the veſtment warm;
In vain his little children, peeping out
Into the mingling ſtorm, demand their ſire,
With tears of artleſs innocence. Alas!
Nor wife, nor children, more ſhall he behold,
Nor friends, nor ſacred home!

With reſpect to the philoſophical account of this well-known meteor, naturaliſts are agreed, that it is formed by the freezing of the vapours in the at-

moſphere. The ſnow we receive, may properly enough be aſcribed to the coldneſs of the atmoſphere through which it falls. When the atmoſphere is warm enough to diſſolve the ſnow, before it arrives to us, we call it rain; if it preſerve itſelf undiſſolved, it makes what we call ſnow. It differs from hoar-froſt, in being cryſtallized, as it were, which they are not. This appears on the examination of a flake of ſnow by a magnifying glaſs; when the whole of it will appear compoſed of fine ſhining ſpicula, or points, diverging like rays from a centre. As the flakes fall down through the atmoſphere, they are continually joined by more of theſe radiated ſpicula, and thus increaſe in bulk like the drops of rain or hailſtones. Dr. Grew, in a diſcourſe on the nature of Snow, obſerves, that many parts of it are of a regular figure, for the moſt part ſo many little rowels or ſtars of ſix points, and are as perfect and tranſparent ice as any we ſee on a pond. Upon each of theſe points are other collateral points, ſet at the ſame angles as the main points themſelves: among which there are divers others irregular, which are chiefly broken points, and fragments of the regular ones. Others alſo, by various winds, ſeem to have been thawed, and frozen again into irregular cluſters; ſo that it ſeems as if the whole body of ſnow was an infinite maſs of icicles irregularly figured. That is, a cloud of vapours being gathered into drops, thoſe drops forthwith deſcend, and, in their deſcent, meeting with a freezing air as they paſs through a colder region, each drop is immediately frozen into an icicle, ſhooting itſelf forth into ſeveral points; but theſe ſtill continuing their deſcent, and meeting with ſome intermitting gales of warmer air, or, in their continual waftage to and fro, touching upon each other, are a little thawed, blunted, and frozen into cluſters, or intangled ſo as to fall down in what we call flakes.

According to ſignior Beccaria, clouds of ſnow differ in nothing from clouds of rain, but in the circumſtance of cold that freezes them. Both the regular diffuſion of ſnow, and the regularity of the ſtructure of its parts (particularly ſome figures of ſnow or hail, which he calls *roſette*, and which fall about Turin) ſhow the clouds of ſnow to be acted upon by ſome uniform cauſe, like electricity. He even endeavours, very particularly, to ſhow in what manner certain configurations of ſnow are made by the uniform action of electricity. He was confirmed in his reaſonings on this ſubject by obſerving, that his apparatus never failed to be electrified by ſnow as well as by rain; and he adds, that a more intenſe electricity nnites the particles of hail more cloſely than the more moderate electricity does thoſe of ſnow.

Snow, although it ſeems to be ſoft, is really hard, becauſe it is true ice. It ſeems ſoft, becauſe at the firſt touch of the finger upon its ſharp edges or points, they melt: otherwiſe they would pierce the finger like ſo many lancets. The lightneſs of ſnow, although it is firm ice, is owing to the exceſs of its ſurface, in compariſon to the matter contained under it; and thus gold, the moſt ponderous of all bodies, when beaten into leaves, will ride upon the leaſt breath of air. The whiteneſs of ſnow is owing to the ſmall particles into which it is divided; for ice, when pounded, will become equally white.—An artificial ſnow has been made by the following experiment. A tall phial of aqua fortis being placed by the fire till it is warm; and filings of pure ſilver, a few at a time, being put into it; after a briſk ebullition, the ſilver will diſſolve ſlowly. The phial being then placed in a cold window, as it cools, the ſilver particles will ſhoot into cryſtals, ſeveral of which running together, will form a flake, reſembling ſnow, and deſcend to the bottom of the phial. While they are deſcending, they repreſent perfectly

a ſhower of ſilver ſnow, and the flakes will lie upon one another, at the bottom, like real ſnow upon the ground.—In a word, a ſhower of ſnow, although ſo common with us, and therefore ſo little regarded, is, in itſelf, a moſt beautiful ſpectacle, and is conſidered by the natives of ſouthern climes, on their arrival here, as the moſt extraordinary and amazing phenomenon of Nature.

But we are not to conſider ſnow merely as a curious and beautiful phenomenon. The great Diſpenſer of univerſal bounty has ſo ordered it, that it is eminently ſubſervient, as well as all the works of creation, to his benevolent deſigns. Were we to judge from appearances only, we might imagine, that ſo far from being uſeful to the earth, the cold humidity of ſnow would be detrimental to vegetation. But the experience of all ages aſſerts the contrary. Snow, particularly in thoſe northern regions where the ground is covered with it for ſeveral months, fructifies the earth, by guarding the corn, or other vegetables, from the intenſer cold of the air, and eſpecially from the cold piercing winds.—It has been a vulgar opinion, very generally received, that ſnow fertilizes the lands on which it falls more than rain, in conſequence of the nitrous ſalts which it is ſuppoſed to acquire by freezing. But it appears from the experiments of Margraaf, in the year 1751, that the chymical difference between rain and ſnow-water is exceedingly ſmall, and that the latter, however, is ſomewhat leſs nitrous, and contains a ſomewhat leſs proportion of earth, than the former; but neither of them contain either earth or any kind of ſalt, in any quantity, which can be ſenſibly efficacious in promoting vegetation! Allowing, therefore, that nitre is a fertilizer of lands, which many are, upon good grounds, diſpoſed utterly to deny, yet ſo very ſmall is the quantity of it contained in ſnow, that it cannot be ſuppoſed to

promote the vegetation of plants upon which the ſnow has fallen. The peculiar agency of ſnow, as a fertilizer, in preference to rain, may, without recurring to nitrous ſalts ſuppoſed to be contained in it, be rationally aſcribed to its furniſhing a covering to the roots of vegetables, by which they are guarded from the influence of the atmoſpherical cold, and the internal heat of the earth is prevented from eſcaping. And hence, Budinus, in his Theatrum Naturæ, obſerves, that the Pſalmiſt, in the paſſage I have quoted above, compares ſnow to wool, rather on account of the warmth it affords to vegetables in the cold of winter, as woollen garments do to men, than of its fleecy reſemblance.—Snow may alſo fertilize the earth, agreeably to the hypotheſis of thoſe who make oil the food of plants, by means of the oily particles which it contains. Beſides, ſnow, in melting, moiſtens and pulverizes the ſoil, which had been bound up by the froſt; and, as its water has a tendency to putrefaction, it ſeems, on many accounts, without admitting it to contain any nitre, to be admirably fitted to promote vegetation.

What themes of grateful adoration does the diſcuſſion of this ſubject ſuggeſt! But I will leave my readers, "in expreſſive ſilence", to "muſe the praiſe" of the great Creator; and ſhall conclude with that beautiful emblem, under which he is ſuppoſed, by the prophet Iſaiah, to repreſent the ſalutary efficacy of his divine word: "As the rain cometh down, and the ſnow from heaven, and returneth not thither, but watereth the earth, and maketh it bring forth and bud, that it may give ſeed to the ſower and bread to the eater; ſo ſhall my word be that goeth forth out of my mouth: it ſhall not return unto me void, but ſhall accompliſh that which I pleaſe, and it ſhall proſper in the thing whereunto I ſent it".

IV. ON WINTER IN THE POLAR REGIONS.

Our infant Winter ſinks,
Diveſted of his grandeur, ſhould our eye
Aſtoniſh'd ſhoot into the frigid zone;
Where, for relentleſs months, continual night
Holds o'er the glitt'ring waſte her ſtarry reign.

THOMSON.

There Winter, arm'd with terrors here unknown,
Sits abſolute on his unſhaken throne;
Piles up his ſtores amid the frozen waſte,
And bids the mountains he has built, ſtand faſt;
Beckons the legions of his ſtorms away
From happier ſcenes to make the land a prey;
Proclaims the ſoil a conqueſt he has won,
And ſcorns to ſhare it with the diſtant ſun.

COWPER.

WINTER, in our temperate regions, exhibits very few phenomenons, in compariſon with what is viſible in the arctic circle. Thomſon, therefore, has judiciouſly enriched his noble concluſion of the Seaſons with all the circumſtances of pictureſque beauty, or terrific grandeur, that could be borrowed from ſcenes far remote from us. The famiſhed troops of wolves pouring from the Alps; the mountains of ſnow rolling down the precipices of the ſame countries; the dreary plains over which the Laplander urges his raindeer; the wonders of the icy ſea; and volcanos flaming through a waſte of ſnow; are objects ſelected, with the greateſt propriety, from all that nature preſents moſt ſingular and ſtriking in the various domains of boreal cold and deſolation.

Among the wintry objects which delight the mind by their beautiful and pictureſque appearance, we may often obſerve the effects of the hoar-froſt, or

of the dew or miſt frozen. This adheres to every object on which it falls, and produces figures of incomparable beauty and elegance. Every twig and blade of graſs is beſet by it with innumerable glittering pearly drops, or ſilver plumage, beyond the ſkill of any artiſt to imitate. Theſe appearances are ſtill more ſtriking the further we proceed to the north. It ſometimes happens that a ſudden ſhower of rain falls during a froſt, and immediately turns to ice. Philips, in his Epiſtle from Copenhagen, has given a beautiful deſcription of ſuch a ſcene; a deſcription which forms as fine a winter piece as we have ever had from the ſchools of the moſt learned painters:

Ere yet the clouds let fall the treaſur'd ſnow,
Or winds began thro' hazy ſkies to blow,
At evening a keen eaſtern breeze aroſe,
And the deſcending rain unſullied froze.
Soon as the ſilent ſhades of night withdrew,
The ruddy morn diſclos'd at once to view
The face of nature in a rich diſguiſe,
And heightened every object to my eyes:
For every ſhrub, and every blade of graſs,
And every pointed thorn, ſeem'd wrought in glaſs;
In pearls and rubies rich the hawthorns ſhow,
While thro' the ice the crimſon berries glow:
The thick-ſprung reeds the wat'ry marſhes yield,
Seem poliſh'd lances in a hoſtile field.
The ſtag, in limpid currents, with ſurpriſe,
Sees chryſtal branches on his forehead riſe:
The ſpreading oak, the beech, the towering pine,
Glaz'd over, in the freezing ether ſhine.
The frighted birds the rattling branches ſhun,
Which wave and glitter in the diſtant ſun.
When if a ſudden guſt of wind ariſe,
The brittle foreſt into atoms flies,
The crackling wood beneath the tempeſt bends,
And in a ſpangled ſhower the proſpect ends.

In ſuch a caſe, prodigious miſchief had been done to

the woods, by the breaking down of vaſt arms of trees which were overloaded by the preſſure of the encruſting ice. At other times, the ſeeming enchantment has been diſſolved in a more gentle way:

For if a ſouthern gale the region warm,
And by degrees unbind the wintry charm,
The traveller a miry country ſees,
And journeys ſad beneath the dropping trees.

As we advance further into the arctic regions, we find them diſtinguiſhed by more beautiful appearances of that phenomenon which we call the *aurora borealis*. In Shetland, theſe northern lights, which the natives call *merry dancers*, are the conſtant attendants of the clear evenings, and prove great reliefs amid the gloom of the long winter nights. They commonly appear at twilight, near the horizon, of a dun colour, approaching to yellow; ſometimes continuing in that ſtate, for ſeveral hours, without any apparent motion; after which they break out into ſtreams of ſtronger light, ſpreading into columns, and altering ſlowly into ten thouſand different ſhapes, varying their colours from all the tints of yellow to the moſt obſcure ruſſet. They often cover the whole hemiſphere, and then make the moſt brilliant appearance. Their motions, at theſe times, are moſt amazingly quick; and they aſtoniſh the ſpectator with the rapid change of their form. They break out in places where none were ſeen before, ſkimming briſkly along the heavens. On a ſudden they are extinguiſhed, and leave behind a uniform duſky tract.

This again is illuminated in the ſame manner, and as ſuddenly left a dull blank. In certain nights they aſſume the appearance of vaſt columns, on one ſide of the deepeſt yellow, on the other declining away till it becomes undiſtinguiſhed from the ſky. They have generally a ſtrong tremulous motion from

end to end, which continues till the whole vaniſhes. In a word, we, who only ſee the extremities of theſe northern phenomenons, have but a faint idea of their ſplendour and their motions.

In Siberia there is one ſpecies of the aurora borealis, which regularly appears between the north-eaſt and eaſt, like a luminous rainbow, with numbers of columns of light radiating from it. Beneath the arch is a darkneſs, through which the ſtars appear with ſome brilliancy. This ſpecies is thought by the natives to be a forerunner of ſtorms. There is another kind, which begins with certain inſulated rays, from the north, and others from the northeaſt. They augment little by little till they fill the whole ſky, and form a ſplendour of colours rich as gold, rubies, and emeralds: but the attendant phenomenons ſtrike the beholders with horror; for they crackle, ſparkle, hiſs, make a whiſtling ſound, and a noiſe even equal to artificial fireworks. The idea of an electrical cauſe is ſo ſtrongly impreſſed by this deſcription, that there can remain no doubt of the origin of theſe appearances. The inhabitants on this occaſion, ſay it is a troop of men furiouſly mad, which are paſſing by. Every animal is ſtruck with terror. Even the dogs of the hunters are ſeized with ſuch dread, that they will fall on the ground, and become immoveable, till the cauſe is over.

In Hudſon's bay, moreover, the firmament, in winter, is not without its beauties. The night is enlivened by the aurora borealis, which ſpreads a thouſand different lights and colours over the whole concave of the ſky, not to be defaced even by the ſplendour of the full moon; and the ſtars are of a fiery redneſs. Mock ſuns and halos are not unfrequent: they are very bright, and richly tinged with all the colours of the rainbow. The ſun alſo riſes and ſets here with a large cone of yellowiſh light.

As we advance further into theſe dreary regions,

we may ſtill meet with thoſe pictureſque objects, that can attract and captivate the moſt incurious eye. In the icy ſeas, and particularly at Spitzbergen (which is the largeſt of that group of frozen iſlands, which go under that name, or that of New Greenland) the forms aſſumed by the ice are extremely pleaſing. The ſurface of that which is congealed from the ſea water (for I muſt allow it two origins) is flat, even, hard, and opake, reſembling white ſugar, and is capable of being ſlid upon. The greater pieces, or fields, are many leagues in length: the ſmaller, are the *meadows* of the ſeals, on which thoſe animals, at times, frolic by hundreds. The motion of the ſmaller pieces is as rapid as the currents: the greater, which are ſometimes 200 leagues long, and ſixty or eighty broad, move ſlowly and majeſtically. They often fix for a time, immoveable by the power of the ocean, and then produce near the horizon, that bright white appearance, called by mariners the *blink of the ice*. The approximation of two great fields produces a moſt ſingular phenomenon: it forces the leſſer (if that term can be applied to pieces ſeveral acres ſquare) out of the water, and adds them to their ſurface: a ſecond, and often a third ſucceeds; ſo that the whole forms an aggregate of a tremendous height. Theſe float in the ſea like ſo many rugged mountains, and are ſometimes five or ſix hundred yards thick; but the far greater part is concealed beneath the water. Theſe are continually increaſed in height by the freezing of the ſpray of the ſea, or of the melting of the ſnow which falls on them. Thoſe which remain in this frozen climate, receive continual growth: others are gradually waſted by the northern winds into ſouthern latitudes, and melt by degrees, by the heat of the ſun, till they waſte away, and diſappear in the boundleſs element.

The colliſion of the great fields of ice, in high latitudes, is often attended with a noiſe, that, for a

time, takes away the power of hearing any thing elſe; and the meeting of the leſſer fields is attended with a grinding of unſpeakable horror. The water which daſhes againſt the mountainous ice freezes into an infinite variety of forms, and gives the voyager ideal towns, ſtreets, churches, ſteeples, and every ſhape which imagination can frame.

The icebergs or glaciers of the northweſt of Spitzbergen are among the capital wonders of the country. The glaciers of Swiſſerland ſeem contemptible to theſe. They are ſeven in number, but at conſiderable diſtances from each other: and each fills the vallies for tracts unknown, in a region totally inacceſſible in the internal parts. The laſt exhibits over the ſea a front 300 feet high, emulating the emerald in colour: cataracts of melted ſnow precipitate down various parts, and black ſpiring mountains ſtreaked with white, bound the ſides, and riſe in the back ground, crag above crag, as far as eye can reach.

At times, immenſe fragments break off, and tumble into the water with a moſt alarming daſhing. A piece of this vivid green ſubſtance has fallen, grounded in twenty-four fathoms water, and ſpired above the ſurface fifty feet. Similar icebergs are common in all the arctic regions; and to their lapſes is owing the ſolid mountainous ice which infeſt thoſe ſeas.

Froſt ſports alſo with theſe icebergs, and gives them majeſtic as well as other moſt ſingular forms. Maſſes have been ſeen aſſuming the ſhape of a Gothic church, with arched windows and doors, and all the rich tracery of that ſtyle, compoſed of what an Arabian tale would ſcarely dare to relate, of cryſtal of the richeſt ſapphirine blue. Tables, with one or more feet, and often immenſe flat-roofed temples, ſupported by round tranſparent columns of cerulean hue, float by the aſtoniſhed ſpectator.—

These icebergs are the creation of ages, and receive annually additional heights, by the falling of snow and rain, which often instantly freezes, and more than repairs the loss by the influence of the melting sun.

Such are part of the wonderful phenomenons of the polar regions. There are other curious particulars, which, with some reflections suitable to the subject, I shall reserve for my next number; concluding this with part of Thomson's magnificent description of the icy regions:

The Muse
Thence sweeps the howling margin of the main;
Where undissolving, from the first of time,
Snows swell on snows amazing to the sky;
And icy mountains high on mountains pil'd,
Seem to the shivering sailor from afar,
Shapeless and white, an atmosphere of clouds.
Projected huge, and horrid, o'er the surge,
Alps frown on Alps; or rushing hideous down,
As if old Chaos was again return'd,
Wide-rend the deep, and shake the solid pole.
Ocean itself no longer can resist
The binding fury; but, in all its rage
Of tempest taken by the boundless frost,
Is many a fathom to the bottom chain'd,
And bid to roar no more! a bleak expanse,
Shagg'd o'er with wavy rocks, cheerless, and void
Of every life, that from the dreary months
Flies conscious southward. Miserable they!
Who here entangled in the gathering ice,
Take their last look of the descending sun;
While, full of death, and fierce with tenfold frost,
The long long night, incumbent o'er their heads,
Falls horrible. Such was the Briton's [a] fate,
As with *first* prow (what have not Britons dar'd!)
He for the passage sought, attempted since

[a] Sir Hugh Willoughby, sent by queen Elisabeth, to discover the northeast passage.

So much in vain, and ſeeming to be ſhut
By jealous nature with eternal bars.
In theſe fell regions, in Arzina caught,
And to the ſtony deep his idle ſhip
Immediate ſeal'd, he with his hapleſs crew,
Each full exerted at his ſeveral taſk,
Froze into ſtatues; to the cordage glued
The ſailor, and the pilot to the helm.

V. FURTHER REFLECTIONS ON THE POLAR WINTER.

Vaſt regions dreary, bleak, and bare!
There on an icy mountain's height,
Seen only by the moon's pale light,
Stern Winter rears his giant form,
His robe a miſt, his voice a ſtorm:
His frown the ſhivering nations fly,
And, hid for half the year, in ſmoky caverns lie.

SCOTT.

IN my preceding paper I deſcribed the pictureſque appearances of the ice in the dreary regions of Spitzbergen. The ſnow, moreover, in thoſe high latitudes, exhibits phenomenons not leſs ſingular than thoſe of the ice. At firſt, it appears ſmall and hard as the fineſt ſand. It then changes its form to that of a hexagonal ſhield, into the ſhape of needles, croſſes, cinquefoils, and ſtars, ſome plain, and ſome ſerrated rays. Theſe forms depend upon the diſpoſition of the atmoſphere; and, in calm weather, the ſnow coaleſces, and falls in cluſters.

The ſingle night of this dreadful country begins about the 30th of October. The ſun then ſets, and never appears till about the 10th of February. A glimmering, indeed, continues ſome weeks after the ſetting of the ſun: then ſucceed clouds and thick

darkneſs, broken by the light of the moon, which is as luminous as in England, and during this long night, ſhines with unfailing luſtre. The cold ſtrengthens with the new year; and the ſun is uſhered in with an unuſual ſeverity of froſt. By the middle of March, the cheerful light grows ſtrong; the arctic foxes leave their holes; and the ſeafowl reſort, in great multitudes, to their breeding places. The ſun ſets no more after the 14th of May. The diſtinction of day and night is then loſt.

In the height of ſummer, the ſun has heat enough to melt the tar on the decks of ſhips; but from Auguſt its power declines: it ſets faſt. After the middle of September, day is hardly diſtinguiſhable, and, by the end of October, takes a long farewell of this country: the days now become frozen, and winter reigns triumphant.

Earth and ſoil are denied to the frozen regions of Spitzbergen. At leaſt, the only thing which reſembles ſoil, is the grit worn from the mountains by the power of the winds, or the attrition of cataracts of melted ſnow. This, indeed, is aſſiſted by the putrefied lichens of the rocks, and the dung of birds, brought down by the ſame means. The compoſition of theſe iſlands is ſtone, formed by the ſublime hand of omnipotent Power; not fritted into ſegments, tranſverſe or perpendicular, but caſt at once into one immenſe and ſolid maſs. A mountain, throughout, is but a ſingle ſtone, deſtitute of fiſſures, except in places cracked by the irreſiſtible power of froſt, which often cauſes lapſes, attended by a noiſe like thunder, and ſcattering over their baſes rude and extenſive ruins.

The vallies, or rather glens, of this country, are filled with eternal ice or ſnow. They are totally inacceſſible, and known only by the divided courſe of the mountains, or where they terminate in the icebergs or glaciers I have already deſcribed. No

ſtreams water their dreary bottoms; and even ſprings are denied. The mariners are indebted for freſh water, ſolely to the periodical cataracts of melted ſnow in the ſhort ſeaſon of ſummer, or to pools in the middle of the vaſt fields of ice.

Yet even here Flora deigns to make a ſhort viſit, and to ſcatter a ſcanty ſtock over the baſes of the hills. Her efforts never riſe beyond a few humble herbs, which ſhoot, flower, and ſeed, in the ſhort warmth of June and July, and then wither into reſt until the ſucceeding year. Among theſe, however, the ſalubrious ſcurvygraſs, the reſource of diſtempered frames, is providentially moſt abundant.

Such, after all, is the aſpect of extreme ſterility and deſolation in theſe dreary regions, that we can ſcarce imagine any mortal would be ſo hardy as to make them even a temporary abode. Yet here did four Ruſſian mariners, who were accidentally left on this frozen coaſt in the year 1743, live ſix years (one excepted) till happily releaſed by the arrival of a ſhip. In 1633, ſeven Dutch ſailors were voluntarily left here to paſs the winter, and to make their remarks; but they all periſhed from the effects of the ſcurvy. In the followlng year, ſeven more ſelf-devoted victims of the ſame nation underwent a ſimilar fate. Yet all theſe adventurous men had been liberally provided with medicines, and every neceſſary for the preſervation of life. Eight Engliſhmen, left by accident in the ſame country, in 1650, were far more fortunate. Unprovided with every thing, they contrived, however, to frame a hut of ſome old materials, and were found by the returning ſhips, the next year, in perfect health. The Ruſſians have lately attempted to colonize theſe dreadful iſlands. They have annually ſent parties to continue there the whole year, who have eſtabliſhed ſettlements at Spitzbergen and other places adjacent, where they have built huts, each of which is oc-

cupied by two boats crews, or twenty-ſix men. They bring with them ſalted fiſh, rye-flour, and the ſerum or whey of ſour milk. The whey is their chief beverage, and is alſo uſed in baking their bread. Each hut has an oven, which ſerves alſo as a ſtove; and their fuel is wood, which they bring with them from Archangel. Their huts are above ground, and ſurpriſingly warm. They boil their fiſh with water and rye-meal: this is their winter diet. In ſummer they chiefly live on fowls, or their eggs. They are dreſſed in the ſkins of the bear or raindeer, with the fur ſide next their bodies. Their bedding, likewiſe, is formed of the ſame. The ſkin of the fox, which is the moſt valuable, is preſerved as an article of commerce. They have alſo other employment beſide the chaſe, in catching with nets the beluga, or white whale. Few of them die from the ſeverity of the cold; but they are often froſt-bitten, ſo as to loſe their toes or fingers; for they are ſo hardy as to hunt in all weathers. They are at liberty to leave the place by the 22nd of September, whether they are relieved by a freſh party from Ruſſia, or not. The great exerciſe they uſe; their vegetable food; their method of freſhening their ſalt proviſion, by boiling it in water, and mixing it with flour; their beverage of whey; and their total abſtinence from ſpirituous liquors; are the happy preſervatives from the ſcurvy, which brought all the preceding adventurers, who periſhed, to their miſerable end.

Where the countries have been long inhabited, in all the arctic coaſts of Europe, Aſia, and America, the natives, with very few variations and exceptions, ſeem to be a diſtinct ſpecies both in body and mind, and not to be derived from the adjacent nations, or any of their better-proportioned neighbours. Their ſtature is from four to four feet and a half; their ſkins ſwarthy, and their hair ſhort, black, and coarſe. Their eyes are tranſverſely narrow, and the irides

black. They have great heads, high cheek-bones, wide mouths, thick lips, broad cheſts, ſlender waiſts, and ſpindle ſhanks. From uſe, they run up rocks like goats, and up trees like ſquirrels. They are ſo ſtrong in the arm, that they can draw a bow which a ſtout Norwegian can hardly bend; yet lazy even to torpidity, when not incited by neceſſity; and puſillanimous and nervous to a hyſterical degree. Theſe are the natives of Finmark and Lapland. The coaſts eaſt of Archangel, as far as the river Oby, are inhabited by the Samoieds; a race as ſhort as the Laplanders, but much uglier, and more brutalized; their food being the carcaſſes of horſes, or any other animals. They uſe the raindeer to draw their ſledges, but are not civilized enough to make it a ſubſtitute for the cow.

Hard by theſe ſhores, where ſcarce his freezing ſtream
Rolls the wild Oby, live the laſt of men;
And half-enlivened by the diſtant ſun,
That rears and ripens man as well as plants,
Here human nature wears its rudeſt form.
Deep from the piercing ſeaſon ſunk in caves,
Here, by dull fires, and with unjoyous cheer,
They waſte the tedious gloom. Immers'd in furs,
Doze the groſs race. Nor ſprightly jeſt, nor ſong,
Nor tenderneſs they know; nor aught of life,
Beyond the kindred bears that ſtalk without.
Till morn at length, her roſes drooping all,
Sheds a long twilight bright'ning o'er their fields,
And calls the quivered ſavage to the chaſe.

THOMSON.

Such are the inhabitants of the greateſt part of the polar regions, and ſuch a ſituation, which, to our imaginations, may appear inſupportable. With the deepeſt veneration for the diſpenſations of divine Providence, a humane mind may ſometimes be apt to inquire, why the benevolent Creator ſhould have deſtined ſuch deplorable ſcenes of deſolation to be

the abode of millions of human beings, while others are bleſſed with temperate climates and ſmiling ſkies, with inexhauſtible harveſts and ſuperfluous profuſion? But good and evil are often merely relative ideas; and much of what we call happineſs on the one hand, and miſery on the other, exiſts leſs in reality than ſentiment. In the Laplanders, for inſtance, the hardy temperament of their bodies, calculated to reſiſt the rigour of their climate; the "furry nations" with which their woods abound, and whoſe ſkins protect them from the cold; and that peculiar bleſſing of theſe regions, the raindeer; are ſo many evidences, that Divine Goodneſs has afforded them many valuable compenſations for all the diſadvantages under which they labour.

They aſk no more than ſimple nature gives;
They love their mountains, and enjoy their ſtorms.
No falſe deſires, no pride-created wants,
Diſturb the peaceful current of their time;
And through the reſtleſs ever-tortur'd maze
Of pleaſure, or ambition, bid it rage.
Their raindeer form their riches. Theſe their tents,
Their robes, their tents, and all their homely wealth
Supply, their wholeſome fare, and cheerful cups.
Obſequious at their call, the docile tribe
Yield to the ſled their necks, and whirl them ſwift
O'er hill and dale, heap'd into one expanſe
Of marbled ſnow, as far as eye can ſweep
With a blue cruſt of ice unbounded glaz'd.
By dancing meteors then, that ceaſeleſs ſhake
A waving blaze refracted o'er the heavens,
And vivid moons and ſtars that keener play
With double luſtre from the gloſſy waſte,
Ev'n in the depth of polar night, they find
A wondrous day: enough to light the chaſe,
Or guide their daring ſteps to Finland-fairs.
Wiſh'd Spring returns; and from the hazy ſouth,
While dim Aurora ſlowly moves before,
The welcome ſun, juſt verging up at firſt,

By ſmall degrees extends the ſwelling curve!
Till ſeen at laſt for gay rejoicing months,
Still round and round, his ſpiral courſe he winds,
And as he nearly dips his flaming orb,
Wheels up again, and reaſcends the ſky.
In that glad ſeaſon from the lakes and floods,
Where pure Niemi's [a] fairy mountains riſe,
And fring'd with roſes [b] Tenglio rolls his ſtream,
They draw the copious fry. With theſe, at eve,
They cheerful loaded to their tents repair;
Where, all day long in uſeful cares employ'd,
Their kind unblemiſh'd wives the fire prepare.
Thrice happy race! by poverty ſecur'd
From legal plunder and rapacious power:
In whom ſelf intereſt never yet has ſown
The ſeeds of vice: whoſe ſpotleſs ſwains ne'er knew
Injurious deed, nor blaſted by the breath
Of faithleſs love, their blooming daughters woe.

THOMSON.

A celebrated writer has ſome obſervations, which beautifully illuſtrate this ſubject. "Of the happineſs and miſery (ſays he) of our preſent ſtate, part ariſes from our ſenſations, and part from our opinions; part is diſtributed by nature, and part is in a great meaſure apportioned by ourſelves. Poſitive pleaſure we cannot always obtain, and poſitive pain we often cannot remove. No man can give to his own plantations the fragrance of the Indian groves; nor will any precepts of philoſophy enable him to withdraw his attention from wounds or diſeaſes. But

[a] M. de Maupertuis, in his book on the Figure of the Earth, after having deſcribed the beautiful lake and mountain of Niemi in Lapland, ſays,—"From this height we had opportunity ſeveral times to ſee thoſe vapours riſe from the lake, which the people of the country call Haltios, and which they deem to be the guardian ſpirits of the mountains. We had been frighted with ſtories of bears that haunted this place, but ſaw none. It ſeemed rather a place of reſort for fairies and genii, than bears".

[b] The ſame author obſerves—"I was ſurpriſed to ſee upon the banks of this river (the Tenglio) roſes of as lively a red as any that are in our gardens".

the negative infelicity, which proceeds not from the preſſure of ſufferings, but the abſence of enjoyments, will always yield to the remedies of reaſon.

" One of the great arts to eſcape ſuperfluous uneaſineſs, is to free our minds from the habit of comparing our condition with that of others on whom the bleſſings of life are more bountifully beſtowed, or with imaginary ſtates of delight and ſecurity, perhaps unattainable by mortals. Few are placed in a ſituation ſo gloomy and diſtreſsful, as not to ſee every day beings more forlorn and miſerable, from whom they may learn to rejoice at their own lot.

" No inconvenience is leſs ſuperable by art or diligence than the inclemency of climates, and therefore none affords more proper exerciſe for this philoſophical abſtraction. A native of England, pinched with the froſts of December, may leſſen his affection for his own country, by ſuffering his imagination to wander in the vales of Aſia, and ſport among woods that are always green, and ſtreams that always murmur; but if he turns his thoughts toward the polar regions, and conſiders the nations to whom a great portion of the year is darkneſs, and who are condemned to paſs weeks and months amid mountains of ſnow, he will ſoon recover his tranquillity, and while he ſtirs his fire, or throws his cloak about him, reflect how much he owes to Providence, that he is not placed in Greenland or Siberia".

Theſe admirable obſervations not only illuſtrate the ſubject, but inculcate leſſons, which, if attended to, will much conduce to diminiſh the preſſure of imaginary evils, and to improve and heighten the happineſs we enjoy. Were we condemned to the dreary climes, and to the manner of life, of the natives of the arctic countries, we ſhould deem it inſupportable. How deplorable ſhould we think our ſituations, if we ſaw nothing before our eyes but

ſtupendous mountains of ice and extenſive waſtes of ſnow; if the abſence of the ſun, for entire months, rendered the cold more inſupportable ſtill; if, inſtead of our comfortable habitations, we had no other aſylum than a gloomy cavern, or a ſkin-covered tent; if we had no other reſource for our ſubſiſtence than a perilous activity in the chaſe; and if we were deprived of all the pleaſures which the arts impart, and of all the ſweets of ſociety that exalt exiſtence, and render life delightful! Let the conſideration, then, of the unſpeakable advantages which we enjoy in our temperate clime, and to which we are ſo inattentive, not only baniſh every repining thought, that we are not placed in ſtill milder regions and ſtill ſerener ſkies, but teach us to regard the Divine Being with increaſing love and unceaſing adoration. In the midſt of thoſe dreary ſcenes, which even "our infant winter" may ſometimes exhibit, let us rejoice in the enchanting proſpect of that delightful ſeaſon, which will ſo ſoon awaken all Nature, and diffuſe warmth, and life, and happineſs around.

Too delicate! reproach no more
The ſeaſons of thy native ſhore;
There ſoon ſhall Spring deſcend the ſky,
With ſmiling brow and placid eye;
A primroſe wreath ſurrounds her hair;
Her green robe floats upon the air;
And ſcatter'd from her liberal hand,
Fair bloſſoms deck the trees, fair flowers adorn the land.

SCOTT.

VI. REFLECTIONS ON THE EXISTENCE OF A SUPREME BEING.

There 's no philoſophy without a God.

BLACKMORE.

By ſteps directing our enraptur'd ſearch
To Him, the Firſt of Minds; the Chief, the Sole.

AKENSIDE.

THE commencement of a new year muſt naturally ſuggeſt to a wiſe man ſome reflections on the years which are now no more, and ſome anxiety concerning thoſe which are yet to come. If his progreſs in knowledge and virtue has been in proportion to the opportunities of acquiſition, a retroſpect of the paſt muſt afford the moſt exquiſite ſatisfaction; and for the future he can entertain no other anxiety, than that the years, which, as it were, have been habitually devoted to God, be not loſt by the guilt or indiſcretion of a moment; but that the ſame vigilance and circumſpection by which he was ſo long enabled to repel temptation; and the ſame ardour in the purſuits of excellence, which had hitherto been productive of ſuch happy effects; may at laſt conduct him to that bleſſed ſituation, which the Pſalmiſt thus emphatically deſcribes: "Mark the perfect man, and behold the upright; for the end of that man is peace".

The firm conviction of a Supreme Being, who is the rewarder of them that diligently ſeek him, is the actuating principle of ſuch a man, in all the viciſſitudes of life. His confidence in the divine protection, his reſignation in the divine will, his habitual regard to the divine preſence; in a word, thoſe hopes of a happier ſtate, which are the ultimate aim of all his purſuits, may be thus expreſſed in the beautiful language of Mrs. Barbauld:

If the ſoft hand of winning Pleaſure leads,
By living waters, and thro' flow'ry meads;
When all is ſmiling, tranquil, and ſerene,
And vernal beauty paints the flatt'ring ſcene;
Oh teach me to elude each latent ſnare,
And whiſper to my fliding heart, *Beware!*
With caution let me hear the ſyren's voice,
And doubtful, with a trembling heart rejoice.
If friendleſs, in a vale of tears, I ſtray,
Where briars wound, and thorns perplex my way,
Still let my ſteady ſoul thy goodneſs ſee,
And with ſtrong confidence lay hold on thee;
With equal joy my various lot receive,
Reſign'd to die, or reſolute to live;
Prepar'd to kiſs the ſceptre, or the rod,
While God is ſeen in all, and all in God.
I read his awful name, emblazon'd high
With golden letters on th' illumin'd ſky;
Nor leſs the myſtic characters I ſee
Wrought in each flow'r, inſcrib'd on ev'ry tree;
In ev'y leaf that trembles on the breeze
I hear the voice of God among the trees;
With thee in ſhady ſolitudes I walk,
With thee in buſy crowded cities talk;
In ev'ry creature own thy forming pow'r,
In each event thy providence adore.
Thy hopes ſhall animate my drooping ſoul,
Thy precepts guide me, and thy fear control.
Thus ſhall I reſt, unmov'd by all alarms,
Secure within the temple of thine arms,
From anxious cares, from gloomy terrors free,
And feel myſelf omnipotent in thee.
Then when the laſt, the cloſing hour draws nigh,
And earth recedes before my ſwimming eye;
Teach me to quit this tranſitory ſcene
With decent triumph and a look ſerene;
Teach me to fix my ardent hopes on high,
And having liv'd to thee, in thee to die.

But to the bulk of mankind, immerſed in the cares of buſineſs, or the purſuits of pleaſure, this ve-

neration of the Divine Being, this confidence in his goodneſs, and acquieſcence in his diſpenſations, ſo far from being habitual, ſeldom form the ſubject of even a momentary meditation; although there is ſcarce an object in the creation, how minute and inſignificant it may ſeem, that does not demonſtrate the exiſtence of a God,

Who, high in glory, and in might ſerene,
Sees and moves all, Himſelf unmov'd, unſeen.

BROOME.

I ſhall here lay before my readers a few arguments to prove this important and ſole eſſential truth: ſay, ſole eſſential truth, becauſe, when we are once effectually convinced of this, a due attention to the nature and circumſtances of this life, as it reſpects another, cannot fail to inſpire a temper of habitual devotion, and lead us to regard obedience to the will of God as the great and joyful buſineſs of our lives; while every thing elſe, in theſe ſublunary ſcenes, will appear, comparatively, of no moment. To conduct ourſelves with propriety, in whatever ſituation it ſhall pleaſe divine Providence to place us, we ſhall conſider as being our principal concern, as that which alone can make us truly happy in this life, and ſolace us with the hopes of immortality.

Nothing can be more evident, than that men, as well as whatever elſe has life, are weak, and dependent creatures, that neither gave exiſtence to themſelves, nor can preſerve it by any power of their own; and, therefore, we muſt certainly be indebted for this exiſtence to ſome ſuperior and more powerful cauſe. And this ſuperior cauſe muſt either be itſelf the firſt cauſe, which is the notion of God, or elſe, by the ſame argument as before, muſt be derived from him, and lead us, conſequently, to the knowledge of him. But this argument, which is called the argument *à priori*, with the various de-

ductions from it, is too abſtruſe for the generality of readers. That admirable metaphyſician and divine, Dr. Clarke, in his Demonſtration of the Being and Attributes of God, has managed this argument with the greateſt perſpicuity and force of reaſoning, by a ſeries of propoſitions mutually connected and dependent, and forming a complete and unanſwerable argument in proof both of the being and attributes of the Deity.

But there is another argument, called the argument *à poſteriori*, which is more generally obvious, and which carries irreſiſtible conviction. This argument is deduced from the frame of the univerſe, and the traces of evident contrivance, and fitneſs of things for each other, that occur through all the parts of it. Theſe conſpire to prove, that the material world, which in its nature is originated and dependent, could not have been the effect of chance or neceſſity, but of intelligence and deſign. The beautiful, harmonious, and beneficial arrangement of the various bodies which compoſe the material ſyſtem; their mutual dependence and ſubſerviency; the regularity of their motions, and the aptitude of theſe motions for producing the moſt beneficial effects; and many phenomenons reſulting from their relation, magnitude, ſituation, and uſe; afford unqueſtionable evidences of the creating power and wiſe diſpoſal of an intelligent and almighty Agent. The power of gravity, by which the celeſtial bodies perſevere in their revolutions, deſerves particular conſideration. This power penetrates to the centres of the ſun and planets, without any diminution of its virtue, and is extended to immenſe diſtances, regularly decreaſing, and producing the moſt ſenſible and important effects. Its action is proportioned to the quantity of ſolid matter in bodies, and therefore ſeems to ſurpaſs mere mechaniſm. But however various the phenomenons which depend on this

power, and may be explained by it, no mechanical principles can account for its effects; much leſs, could it have produced at the beginning, the regular ſituation of the orbs, and the preſent diſpoſition of things. Gravity could not have determined the planets to move from weſt to eaſt in orbits nearly circular, almoſt in the ſame plane; nor could this power have projected the comets with all the variety of their directions. If we ſuppoſe the matter of the ſyſtem to be accumulated in the centre by its gravity, no mechanical principles, with the aſſiſtance of this power, could ſeparate the huge and unweildy maſs into ſuch parts as the ſun and planets; and, after carrying them to their different diſtances, project them in their ſeveral directions, preſerving ſtill the quality of action and reaction, or the ſtate of the centre of gravity of the ſyſtem [a]. Such an exquiſite ſtructure of things could ariſe from the contrivance and powerful influences only of an intelligent, free, and omnipotent Agent. The ſame powers, therefore, which, at preſent, govern the material univerſe, and conduct its various motions, are very different from thoſe, which were neceſſary to have produced it from nothing, or to have diſpoſed it in the admirable form in which it now proceeds.

But I ſhould far exceed the limits of this paper, if, confining my obſervation to the earth, our own habitation, I were to enumerate only the principal traces of deſign and wiſdom, as well as goodneſs, which are diſcernible in its figure and conſtituent parts, in its diurnal and annual motion, in the poſition of its axis with regard to its orbit, in the benefit which it derives from the light and heat of the ſun, and the alternate viciſſitude of the ſeaſons; in the atmoſphere which ſurrounds it; and in the different ſpecies and varie-

[a] See No. XI. On Gravity.

ties of vegetables and animals with which it is replenished. No one can survey the vegetable productions of the earth, so various, beautiful, and useful; nor the gradations of animal life, in such a variety of species, all preserved distinct, and propagated by a settled law; each fitted to its own element, provided with proper food, and with instincts and organs suited to its rank and situation, and especially with the powers of sensation and self-emotion, and all more immediately or remotely subservient to the government and use of man, without admiring the skill and design of the original founder. But these are more signally manifested in the structure of the human frame, and in the noble powers and capacities of the human mind; more especially in the moral principles and faculties, which are a distinguishing part of our constitution, and lead to the perception and acknowledgement of the existence and government of God. In those instances that have now been recited, and a variety of similar instances suggested by them, or naturally recurring to the notice of the curious and reflecting mind, contrivance is manifest, and immediately without any nice or subtle reasoning, suggests a contriver. It strikes us like a sensation; and artful reasonings against it may puzzle us, without shaking our belief. No person, for example, that knows the principles of optics, and the structure of the eye, can believe that it was formed without skill in that science; or that the ear was formed without the knowledge of sounds; or that the male and female, created and preserved in due proportion, were not formed for each other, and for the continuing of the species. All our accounts of Nature are full of instances of this kind. The admirable and beautiful structure of things for final causes, exalts our idea of the Contriver; and the unity of design shows him to be one. The great motions in the system, performed with the same fa-

cility as the leaſt, ſuggeſt his almighty power, who gave motion to the earth and the celeſtial bodies with equal eaſe as to the minuteſt particles; the ſubtilty of the motions and actions in the internal parts of bodies ſhows that his influence penetrates the inmoſt receſſes of things, and that he is equally active and preſent every where. The ſimplicity of the laws that prevail in the world, the excellent diſpoſition of things, in order to obtain the beſt ends; and the beauty which adorns the works of nature, far ſuperior to any thing in art, ſuggeſt his conſummate wiſdom. The uſefulneſs of the whole ſcheme, ſo well contrived for the intelligent beings that enjoy it, with the internal diſpoſition and moral ſtructure of thoſe beings, ſhows his unbounded goodneſs. Theſe are arguments which are ſufficiently open to the views and capacities of the unlearned, while, at the ſame time, they acquire new ſtrength and luſtre from the diſcoveries of the learned. The Deity, by acting and interpoſing in the univerſe, demonſtrates, that he not only formed it, but rules over it; and the depth of his counſels, even in conducting the material univerſe, of which a great part ſurpaſſes our knowledge, tends to preſerve an inward veneration and awe of this great Being, and diſpoſes us to receive what may be otherwiſe revealed concerning him. His eſſence, as well as that of all other ſubſtances, is beyond the reach of all our diſcoveries, but his attributes appear clearly in his admirable works. We know that the higheſt conceptions we are able to form of them are ſtill beneath his real perfections; but his dominion over us, and our duty toward him, are manifeſt.

I ſhall conclude this paper with ſome obſervations on the Divine Benevolence, by a celebrated author, which admirably illuſtrate my preſent ſubject: "When God (ſays he) created the human ſpecies, either he wiſhed their happineſs, or he wiſhed their

miſery, or he was indifferent and unconcerned about both.

"If he had wiſhed our miſery, he might have made ſure of his purpoſe, by forming our ſenſes to be as many ſores and pains to us, as they are now inſtruments of gratification and enjoyment; or by placing us amid objects ſo ill ſuited to our perceptions, as to have continually offended us, inſtead of miniſtering to our refreſhment and delight. He might have made, for example, every thing we taſted bitter; every thing we ſaw loathſome; every thing we touched a ſting; every ſmell a ſtench; and every ſound a diſcord.

"If he had been indifferent about our happineſs or miſery, we muſt impute to our good fortune (as all deſign by this ſuppoſition is excluded) both the capacity of our ſenſes to receive pleaſure, and the ſupply of external objects fitted to produce it.

"But either of theſe, and ſtill more both of them, being too much to be attributed to accident, nothing remains but the firſt ſuppoſition, that God, when he created the human ſpecies, wiſhed their happineſs; and made for them the proviſion which he has made, with that view, and for that purpoſe.

"The ſame argument may be propoſed in different terms, thus: Contrivance proves deſign; and the predominant tendency of the contrivance indicates the diſpoſition of the deſigner. The world abounds with contrivances; and all the contrivances which we are acquainted with, are directed to beneficial purpoſes. Evil no doubt exiſts; but is never, that we can perceive, the object of contrivance. Teeth are contrived to eat, not to ache; their aching now and then is incidental to the contrivance, perhaps, inſeparable from it: or even, if you will, let it be called a defect in the contrivance; but it is not the object of it. This is a diſtinction which well deſerves to be attended to. In deſcribing im-

plements of huſbandry, you would hardly ſay of a ſickle, that it is made to cut the reaper's fingers, though from the conſtruction of the inſtrument, and the manner of uſing it, this miſchief often happens. But if you had occaſion to deſcribe inſtruments of torture or execution, this engine, you would ſay, is to extend the ſinews; this to diſlocate the joints; this to break the bones; this to ſcorch the ſoles of the feet. Here pain and miſery are the very objects of the contrivance. Now nothing of this ſort is to be found in the works of nature. We never diſcover a train of contrivance to bring about an evil purpoſe. No anatomiſt ever diſcovered a ſyſtem of organization, calculated to produce pain and diſeaſe; or, in explaining the parts of the human body, ever ſaid, this is to irritate; this to inflame; this duct is to convey the gravel to the kidneys; this gland to ſecrete the humour, which forms the gout; if by chance he come at a part of which he knows not the uſe, the moſt he can ſay is, that it is uſeleſs; no one ever ſuſpects that it is put there to incommode, to annoy, or torment. Since then God hath called forth his conſummate wiſdom to contrive and provide for our happineſs, and the world appears to have been conſtituted with this deſign at firſt, ſo long as this conſtitution is upholden by him, we muſt in reaſon ſuppoſe the ſame deſign to continue.

"There is always a ſingle example, by which each man finds himſelf more convinced than by all others put together. I ſeem, for my own part, to ſee the benevolence of the Deity more clearly in the pleaſures of very young children, than in any thing in the world. The pleaſures of grown perſons may be reckoned partly of their own procuring; eſpecially if there has been any induſtry, or contrivance, or purſuit, to come at them; or if they are founded, like muſic, painting, &c. upon any qualification of their own acquiring. But the pleaſures of a healthy

infant are ſo manifeſtly provided for it by another, and the benevolence of the proviſion is ſo unqueſtionable, that every child I ſee at its ſport affords to my mind a kind of ſenſible evidence of the finger of God, and of the diſpoſition which directs it".

VII. REFLECTIONS ON THE SOLAR SYSTEM.

Quid poteſt eſſe tam apertum, tamque perſpicuum, cum cœlum ſuſpeximus, cœleſtiaque contemplati ſumus, quam eſſe aliquod Numen præſtantiſſimæ mentis, quo hæc regantur? CICERO.

The heavens declare the glory of God, and the firmament ſhoweth forth his handy work. DAVID.

WHEN Winter extends his deſolate domain, and we are deprived of all the beauties of contemplation in the vegetable world, the radiant orbs on high ſtill ſhine with undiminiſhed ſplendour, and inſpire the religious philoſopher with the moſt awful ſentiments of wonder and devotion. Their prodigious magnitude and diſtances, with the regularity and harmony of their motions, all concur to declare, with the eloquent heathen philoſopher and the royal Pſalmiſt above, that, "the hand that formed them is divine".

It is no wonder, then, that aſtronomy is a ſcience of the earlieſt antiquity, and that it has claimed the admiration of all ages. Poets, philoſophers, and hiſtorians, have all beſtowed upon it the higheſt encomiums; and even kings[a] have enriched it with

[a] Belus, king of Aſſyria; Atlas, king of Mauritania; and Uratus, king of the country ſituate on the ſhore of the Atlantic ocean; are ſeverally recorded, as the perſons to whom the world owes this noble ſcience; and, among the moderns, Alphonſus, king of Caſtile, enriched it with thoſe tables that ſtill bear his name.

their labours. The poets, in particular, have been laviſh in their praiſes of this ſubject[a]. Of theſe, however, I ſhall be content to ſelect a few only from the magnificent effuſions of Young, whoſe ſublime muſe was more particularly devoted to nocturnal contemplations.

How is Night's ſable mantle labour'd o'er,
How richly wrought with attributes divine!
What wiſdom ſhines! what love! This midnight pomp,
This gorgeous arch, with golden worlds inlaid!
Built with divine ambition! nought to Thee:
For others this profuſion—

The ſoul of man, His face deſign'd to ſee,
Who gave theſe wonders to be ſeen by man,
Has here a previous ſcene of objects great
On which to dwell; to ſtretch to that expanſe
Of thought, to riſe to that exalted height
Of admiration, to contract that awe,
And give her whole capacities that ſtrength,
Which beſt may qualify for final joy.

This proſpect vaſt, what is it?—Weigh'd aright,
'Tis nature's ſyſtem of divinity,
And every ſtudent of the night inſpires.
'Tis elder ſcripture writ by God's own hand.

What read we here?—Th' exiſtence of a God?—
Yes, and of other beings, man above;
Natives of ether, ſons of higher climes!

Why from yon arch, that infinite of ſpace,
With infinite of lucid orbs replete,
Which ſet the living firmament on fire,
At the firſt glance, in ſuch an overwhelm
Of wonderful, on man's aſtoniſh'd ſight
Ruſhes Omnipotence?

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[a] Manilius, a Roman poet, wrote a poem on Aſtronomy, of which five books are extant.

Night opes the nobleſt ſcenes, and ſheds an awe,
Which gives thoſe venerable ſcenes full weight,
And deep reception in th' intender'd heart.
This gorgeous apparatus! This diſplay!
This oſtentation of creative power!
This theatre!—what eye can take it in?
By what divine enchantment was it rais'd,
For minds of the firſt magnitude to launch
In endleſs ſpeculation, and adore?
One ſun by day, by night ten thouſand ſhine;
And light us deep into the Deity;
How boundleſs in magnificence and might!

Bright legions ſwarm unſeen, and ſing, unheard
By mortal ear, the glorious Architect,
In this his univerſal temple, hung
With luſtres, with innumerable lights,
That ſhed religion on the ſoul; at once,
The temple and the preacher! O how loud
It calls Devotion! genuine growth of Night!
—Devotion! daughter of Aſtronomy!
An undevout aſtronomer is mad.

What magnificent ideas of the Creator and his works, indeed, does the ſtarry firmament preſent! How far ſuperior the ſubject to the moſt ſublime conceptions of the human mind! The Sun, that glorious luminary, which is only viſible to us by day, is a ſtupendous body of fire, placed in the centre of our univerſe. Around his orb, other globes, called planets, ſatellites, and comets, perform their revolutions with the moſt perfect order and regularity[a].

The planets are all opaque ſpherical bodies, like our Earth. They have no proper light of their own; but ſhine by the reflected light which they receive from the Sun; the teleſcope having demonſtrated, that only that ſide of them is illuminated, which is turned toward him. They are not only ſimilar to the Earth in form and ſtructure, but they have alſo,

[a] See a Philoſophical Account of the Sun in No. XLIII.

like her, their annual and diurnal revolutions. From the regular appearance and diſappearance of ſome remarkable dark ſpots, which are diſcernible on their bodies by the teleſcope, it is certain, that they muſt have ſuch a motion round their axes, as anſwers to the diurnal revolution of the Earth; and, from their appearing ſometimes to be ſtationary, and at other times retrogade, it is equally evident, that they muſt have ſuch a progreſſive motion round the Sun, as anſwers to the annual revolution of the Earth.

The neareſt planet to the Sun is Mercury, which revolves round him in about 87 days and 23 hours, which is the length of his year. Being ſeldom ſeen, however, on account of his proximity to the Sun, and no ſpots appearing on his diſk, the time of his rotation upon his axis is ſtill unknown. His diſtance from the Sun is computed to be 36,800,000 miles; his diameter 3,100; and, in his circuit round the Sun, he moves at the rate of 105,000 miles an hour.

The next planet beyond Mercury is Venus, which is computed to be 68,800,000 miles from the Sun. She completes her annual rotation in 224 days and 17 hours, moving at the rate of 76,000 miles an hour. Her diameter is 7700 miles, and her diurnal revolution is performed in 23 hours and 22 minutes. When this planet appears to the weſt of the Sun, ſhe riſes before him in the morning, and is called the Morning Star [a]; and when ſhe appears to the eaſt of the Sun, ſhe ſhines in the evening after he is ſet, and is then called the Evening Star [b]. She is

[a] Faireſt of ſtars, laſt in the train of night,
If better thou belong not to the dawn,
Sure pledge of day, that crown'ſt the ſmiling morn
With thy bright circlet, praiſe him in thy ſphere,
While day ariſes, that ſweet hour of prime. MILTON.

[b] Fair Venus ſhines
Even in the eye of day; with ſweeteſt beam
Propitious ſhines, and ſhakes a trembling flood
Of ſoften'd radiance from her dewy locks. BARBAULD.

in each ſituation, alternately, for about 290 days; and, during the whole of her revolution, ſhe appears, through a teleſcope, to have all the various ſhapes and appearances of the Moon.

The Earth is the next planet in the ſyſtem, whoſe diſtance from the Sun is 95,100,000 miles. She moves at the rate of 58,000 miles an hour, completing her annual circuit in 365 days 5 hours and 49 minutes; which motion, though 120 times ſwifter than that of a cannon-ball, is but little more than half the velocity of Mercury in his orbit. Her diameter is about 7900 miles; and, as ſhe turns round her axis every twenty-four hours, from weſt to eaſt, it occaſions an apparent motion of all the heavenly bodies, from eaſt to weſt, in the ſame time.

Next beyond the orbit of the Earth is Mars, whoſe diſtance from the Sun is computed to be 145,000,000 miles. He moves at the rate of 55,000 miles an hour, and completes his revolution round the Sun in a little leſs than two of our years. His diameter is 5100 miles; and his diurnal rotation is performed in 24 hours and 39 minutes. He ſometimes appears gibbous, but never horned, like the Moon, which plainly ſhows, that his orbit includes that of the Earth, and that he ſhines not by any native light.

After Mars is Jupiter, the largeſt of all the planets, whoſe diſtance from the Sun is computed to be 494,990,000 miles. He travels at the rate of 29,000 miles an hour, and completes his annual revolution in ſomething leſs than 12 of our years. His diameter is computed to be 94,100 miles; and by a prodigiouſly rapid motion upon his axis, he performs his diurnal rotation in nine hours and fifty-ſix minutes.

Saturn, the next planet beyond Jupiter, is about 908,000,000 miles from the Sun. He travels at the rate of 22,000 miles an hour, and performs his an-

nual circuit in about twenty-nine and a half of our years. His diameter is computed to be 78,000 miles, and his diurnal rotation is performed in ten hours and ſixteen minutes.

The Georgian, the moſt remote planet in the ſyſtem, was diſcovered on the 13th of March 1781, by Mr. Herſchel, who gave it the name of Georgium Sidus, but moſt foreign aſtronomers call it by his own name. Its diſtance from the Sun is 1,816,400,000 miles, its diameter 35,200, and it revolves round the Sun, at the rate of 7000 miles an hour, in about eighty-two years. The time of its rotation upon its axis is yet unknown.

Beſide the primary planets here mentioned, there are eighteen others, called ſecondary planets, or ſatellites, which regard their primaries as the centres of their motions, and revolve round them in the ſame manner as thoſe primaries do round the Sun.

One of the moſt conſpicuous of theſe ſatellites is the Moon, which is a conſtant attendant on the Earth; and, while ſhe accompanies it in its annual progreſs through the heavens, keeps revolving round it continually, by a different motion, in the ſpace of a month. The diameter of the Moon is 2180, her diſtance from the Earth 240,000 miles; and in bulk ſhe is ſixty times leſs than the Earth. Jupiter has four ſuch moons, Saturn ſeven, and the Georgian ſix: and from the continual change of their phaſes or appearances, it is evident, that theſe alſo are opaque bodies, like the planets, and ſhine only by the means of the borrowed light, which they receive from the Sun.

It may be obſerved alſo, that our Earth is a moon to the Moon, waxing and waning in exactly the ſame manner, but appearing about thirteen times larger, and, of courſe, affording a proportional quantity of light. When ſhe changes on us, the Earth will appear full to her, and when ſhe is in her firſt

quarter to us, the Earth will be in its third quarter to her. And as her axis is almoſt perpendicular to the plane of the ecliptic, one half of her orb will be conſtantly illuminated by the reflected light afforded by the Earth in the Sun's abſence, and the other will have a fortnight's light, and a fortnight's darkneſs alternately.—The rotation of the Moon round the Earth is alſo performed exactly in the ſame time, that ſhe goes once round the Earth, as is evident from her always preſenting the ſame face to us during the whole of her monthly revolution, and, on this account, it is plain, that the inhabitants of one half of the lunar world are totally deprived of a ſight of the Earth, and muſt for ever remain ignorant of its exiſtence, unleſs buſineſs or pleaſure lead them to explore the oppoſite hemiſphere; where they may have a full view of our globe, moving majeſtically through the heavens, and appearing to them like a newly-created planet, of a magnitude near thirteen times larger than that of the Sun [a].

Beſide their moons, the two planets, Jupiter and Saturn, are diſtinguiſhed from the reſt in a manner ſtill more remarkable, and particularly the latter. The body of Jupiter is ſurrounded by ſeveral parallel faint ſubſtances called Belts; and Saturn not only has the ſame belt-like appearances, but alſo a magnificent luminous ring, which encompaſſes him, at ſuch a diſtance, that ſtars may frequently be ſeen between the inward ſurface of the ring and the body of the planet. But neither theſe appearances, nor the ſatellites themſelves, can be diſcerned without the aſſiſtance of a teleſcope.

The comets are now the only objects in our ſyſtem that remain to be mentioned; but the conſideration of theſe, and of the infinity of ſtars that cover the whole face of the heavens, I reſerve for my ſuc-

[a] See various other particulars concerning the Moon in No. XXII.

ceeding paper, and conclude this in the beautiful language of Thomſon:

With what an awful world-revolving pow'r
Were firſt th' unwieldy planets launch'd along
Th' illimitable void! There to remain,
Amid the flux of many thouſand years,
That oft has ſwept the toiling race of men,
And all their labour'd monuments away.
Firm, unremitting, matchleſs in their courſe,
To the kind temper'd change of night and day,
And of the ſeaſons ever ſtealing round,
Minutely faithful: ſuch th' All-perfect Hand,
That pois'd, impels, and rules the ſteady Whole.

VIII. ON COMETS.

Haſt thou ne'er ſeen the comet's flaming flight?
Th' illuſtrious ſtranger paſſing, terror ſheds
On gazing nations, from his fiery train
Of length enormous; takes his ample round
Through depths of ether; coaſts unnumber'd worlds
Of more than ſolar glory; doubles wide
Heav'n's mighty cape, and then reviſits earth,
From the long travel of a thouſand years. YOUNG.

THE aſtronomy of comets may be properly ſaid to be yet in its infancy, no advances having been made in it before the 17th century. With reſpect to the ancients, they knew very little of their nature or motions. Some conſidered them as wandering ſtars: others ſuppoſed them to be mere appearances, formed either by reflections or refractions of the ſun's beams, having no real or diſtinct ſubſtance from other celeſtial bodies. Others believed them to be fiery meteors, generated of bituminous exhalations from

our terraqueous globe, which being elevated to the higher regions of the atmoſphere, were there ſet on fire, and continued their appearance till all their ſulphureous particles were conſumed; while others conſidered them only as ominous phenomenons, diſplayed by the ſupreme Being to terrify mankind, and warn them of the approach of ſome dreadful calamity. And the ſame opinion prevailed during the dark ages between the decline of the Roman empire and the Reformation.

The poets have frequently compared a hero in his ſhining armour to a comet, and as poetry delights in omens, prodigies, and ſuch wonderful events as were ſuppoſed to follow upon the appearance of comets, eclipſes, and the like, they never fail to make ſome alluſion to the popular ſuperſtition on this ſubject. Thus Homer, Virgil, and Taſſo, who have been copied by Milton, in his fine compariſon of Satan to a comet:

Incens'd with indignation, Satan ſtood
Unterrified, and like a comet burn'd,
That fires the length of Ophiucus huge
In th' arctic ſky, and from his horrid hair
Shakes peſtilence and war.

Milton has here exceeded his originals in ſublimity; and his compariſon is applied with much greater propriety than theirs; for they deſcribe only a mortal hero, but Milton is ſpeaking of a ſuperhuman being.—I ſhall give two more quotations, in which, I think, the popular opinion is not only poetically, but philoſophically mentioned:

In Fancy's eye encountering armies glare,
And ſanguine enſigns wave unfurl'd in air[a]!
Hence the deep vulgar deem impending fate,
A monarch ruin'd, or unpeopled ſtate.

[a] The aurora borealis: for an account of the remarkable appearances of which meteor, ſee No. LI.

Thus comets, dreadful viſitants! ariſe,
To them wild omens, ſcience to the *wiſe!*
Theſe mark the comet to the ſun incline,
While deep-red flames around its centre ſhine!
While its fierce rear a winding trail diſplays,
And lights all ether with the ſweeping blaze!
Or when, compell'd, it flies the torrid zone,
And ſhoots by worlds unnumber'd and unknown;
By worlds, whoſe people, all aghaſt with fear,
May view that miniſter of vengeance near!
Till now, the tranſient glow, remote and loſt,
Decays, and darkens 'mid involving froſt!
Or when it, ſunward, drinks rich beams again,
And burns imperious on th' ethereal plain!
The learn'd-one curious eyes it from afar,
Sparkling through night, a new illuſtrious ſtar!

SAVAGE.

Amid the radiant orbs,
That more than deck, that animate the ſky,
The life-infuſing ſuns of other worlds;
Lo! from the dread immenſity of ſpace
Returning with accelerated courſe,
The ruſhing comet to the ſun deſcends;
And as he ſinks below the ſhaded earth,
With awful train projected o'er the heav'ns,
The guilty nations tremble. But, above
Thoſe ſuperſtitious horrors that enſlave
The fond ſequacious herd, to myſtic faith
And blind amazement prone, th' enlighten'd few
Whoſe godlike minds philoſophy exalts,
The glorious ſtranger hail. They feel a joy
Divinely great; they in their powers exult,
That wondrous force of thought, that mounting ſpurns
This duſky ſpot, and meaſures all the ſky;
While, from his far excurſion through the wilds
Of barren ether, faithful to his time,
They ſee the blazing wonder riſe anew,
In ſeeming terror clad, but kindly bent
To work the will of All-ſuſtaining Love:
From his huge vapoury train perhaps to ſhake
Reviving moiſture on the numerous orbs,

Through which his long ellipſis winds; perhaps
To lend new fuel to declining ſuns,
To light up worlds, and feed th' eternal fire.

THOMSON.

When the terrors, which ſuperſtition and aſtrology formerly excited, had fled before the dawn of philoſophy; when Newton, unfolding the ſyſtem of the univerſe, had deſcribed the laws by which the motions of comets are directed, and Halley had carried the theory of his illuſtrious predeceſſor to a high degree of certitude and perfection, their diſcoveries gave riſe to a new kind of anxiety and apprehenſion. It was feared, that ſome of the comets, which move in all directions through the different regions of our planetary ſyſtem, might, ſome time or other, meet with our earth in its courſe; and it was ſuppoſed, that ſome rencounters may have already happened, and produced the revolutions of which the veſtiges are to be found in ſeveral parts of our globe. Thus Whiſton conſidered the general flood as an inundation produced by the tail of a comet, and ſuppoſed that the univerſal conflagration will be occaſioned by the earth's meeting with one of thoſe bodies on its return from the ſun. Maupertuis imagined, that the tails of comets, by mixing their exhalations with our atmoſphere, might have a noxious influence upon the health of animals and the growth of plants. He further apprehended, that their attraction might, ſome time or other, oblige our globe to change its orbit, and to revolve about one of them in the character of a ſatellite, or at leaſt, expoſe it to more violent viciſſitudes of heat and cold than it experiences at preſent. But theſe terrors are merely viſionary: and have been refuted in an eſſay on this ſubject, by M. Dionis du Sejour. This work [a], which contains the beſt theory of comets hitherto publiſhed, has the

[a] Eſſai ſur les Comets en general, &c. Paris 1775.

double merit of having given new degrees of perfection and improvement to the ſcience of aſtronomy, and of calming the fears and apprehenſions of mankind, by ſhowing, that we have abſolutely little or nothing to fear from thoſe flaming bodies, which ignorance and ſuperſtition have rendered ſo terrible.

Comets, according to ſir Iſaac Newton, are compact, ſolid, fixed, and durable bodies: in one word, a kind of planets; which move in very oblique orbits, every way with the greateſt freedom; perſevering in their motions, even againſt the courſe and direction of the planets: and their tail is a very thin ſlender vapour, emitted by the head or nucleus of the comet, ignited or heated by the ſun.

From the lights which this great philoſopher has thrown upon this abſtruſe part of aſtronomy, there is reaſon to think, that ſucceeding aſtronomers will carry it to the greateſt degree of perfection. But although we are indebted to him for a true theory of the *motion* of the comets, yet, with reſpect to the formation of their *tails*, and the *uſes* for which theſe great bodies are intended, his opinions have been controverted. Dr. Hamilton, in particular, in his Philoſophical Eſſays, controverts ſir Iſaac's opinion. He aſſerts, from a view of the phenomenons of a comet, that the matter which conſtitutes its tail, is not an illuminated vapour, but a *ſelf-ſhining ſubſtance*, which, in all poſitions of the comet, and whatever be the direction of its motion, whether toward or from the ſun, is thrown off from its dark hemiſphere, in a direction oppoſite to the ſun, a ſhort time before and after its perihelion, or neareſt approach to that luminary. He finds, moreover, in the aurora borealis, a matter which greatly reſembles it in appearance, its ſituation with regard to the ſun and to the body whence it flows, as well as in the nature of its ſubſtance, ſo far as it is known to us: for the aurora borealis is likewiſe a rare and lucid ſubſtance,

thrown off in a direction nearly oppoſite to the ſun, from the dark hemiſphere of the earth; tending toward the zenith of the ſpectator, or the *vertex* of the earth's ſhadow; riſing principally from the northern part of the earth's atmoſphere, and moſt frequently viſible while the ſun is paſſing through the ſouthern ſigns, and the earth moving from the autumnal to the vernal equinox, through that half of its orbit which is neareſt to the ſun; and laſtly, not intercepting, in any ſenſible degree, the light of the fixed ſtars: ſo that, to a ſpectator placed at a conſiderable diſtance from the earth, and ſhaded from the ſun's light, it muſt appear as a tail to the earth; ſmall, indeed, in proportion to the earth's diameter, but in its direction, ſituation, tranſparency, and lucid appearance, reſembling that of a comet.

Abbé Mann, a learned Engliſhman, long reſident at Bruſſels, has likewiſe ſhown, by unanſwerable arguments, that there is a manifeſt and perfect analogy between the tails of theſe great and luminous bodies and the aurora borealis. Hence he concludes, that they both proceed from the ſame principle, and are formed of the ſame matter; that they are emanations of the electrical fluid from their reſpective bodies, and that this fluid often becomes a phlogiſton, by the heterogeneous mixtures which it carries along with it in this emanation, which accounts for the different colours and other circumſtances in theſe meteors.—"As electrics (ſays the abbé) when ſufficiently heated, become conductors of the electrical fluid, and yield emanations of it in proportion to the quantity they naturally contain, this is preciſely the caſe with the earth and the comets in their perihelia. The approach of the comets to the ſun, and the ſuperabundant degree of heat, which they receive from this approach, diſpoſe them to ſend forth a proportionable part of the electrical fluid, whoſe emiſſion produces all the phenomenons we obſerve in the tails

of comets, the auroræ boreales, and ſeveral electrical experiments. Theſe phenomenons therefore, have the ſame cauſe, and one common principle. In the receſs of the comet and its increaſing diſtance from the ſun, this viſible emiſſion of electrical matter diminiſhes gradually, and at laſt totally diſappears, and inſtead of being an electrical conductor, which it was in its perihelion, it attracts the fluid, is charged with it anew, and thus becomes electric until its approach to the ſun, and the heat it acquires thereby, change it again into a conductor [a]".

From the prodigious activity of the electrical fluid, its tendency to eſcape from the bodies which contain it, and to diffuſe itſelf in the vaſt planetary regions, which come the neareſt to void ſpace, the ingenious abbé draws ſome conjectures relative to the uſes and the end which comets may ſerve in the planetary ſyſtem. He thinks, that comets are real electrical bodies, deſigned to collect the electrical fluid, which has eſcaped from the planets; that the comets, heated by their approximation to the ſun, communicate this fluid anew to the planets; and thus the perpetual circulation of this active fluid, ſo neceſſary to the great *whole*, is maintained and renewed inceſſantly; and that the operations of nature in the planetary ſyſtem, are carried on in a manner analogous to what we conſtantly obſerve and experience in the perpetual circulations of our atmoſphere, where winds, vapours, and exhalations riſe and float; then return to us in rain, ſnow, and fulminating exploſions; and then again are exhaled and raiſed anew. "Every thing (he judiciouſly obſerves) is analogous and harmonical in univerſal nature."

I ſhall conclude this paper with the moral reflections of an elegant writer: "I cannot forbear re-

[a] Memoir concerning Electrical Fire, &c. in Memoirs of the Academy at Bruſſels, vol. ii.

flecting on the inſignificance of human art, when ſet in compariſon with the deſigns of Providence. In the purſuit of this thought, I conſidered a comet, or in the language of the vulgar, a blazing ſtar, as a ſky rocket diſcharged by a hand that is Almighty. Many of my readers ſaw that in the year 1680, and if they are not mathematicians, will be amazed to hear, that it travelled with a much greater degree of ſwiftneſs than a cannon-ball, and drew after it a tail of fire that was fourſcore millions of miles in length. What an amazing thought is it to conſider this ſtupendous body traverſing the immenſity of the creation with ſuch a rapidity, and at the ſame time wheeling about in that line which the Almighty had preſcribed for it! That it ſhould move in ſuch inconceivable fury and combuſtion, and at the ſame time with ſuch an exact regularity! How ſpacious muſt the univerſe be, that gives ſuch bodies as theſe their full play, without ſuffering the leaſt diſorder or confuſion by it! What a glorious ſhow are thoſe beings entertained with, that can look into this great theatre of nature, and ſee myriads of ſuch tremendous objects wandering through thoſe immeaſurable depths of ether, and running their appointed courſes! Our eyes may hereafter be ſtrong enough to command this magnificent proſpect, and our underſtandings able to find out the ſeveral uſes of theſe great parts of the univerſe. In the mean time, they are very proper objects for our imagination to contemplate, that we may form more extenſive notions of infinite wiſdom and power, and learn to think humbly of ourſelves, and of all the little works of human invention[a]".

[a] Guardian, No. 103.

IX. ON A PLURALITY OF WORLDS.

Nor to this evaneſcent ſpeck of earth
Poorly confined, the radiant tracts on high
Are *our* exalted range; intent to gaze
Creation through; and, from that full complex
Of never-ceaſing wonders, to conceive
Of the Sole Being right, who ſpoke the word,
And Nature moved complete.

* * * * * * * *

Oh Nature! all-ſufficient! over all!
Enrich me with the knowledge of thy works!
Snatch me to heaven; and ſhow thy wonders there,
World beyond world, in infinite extent,
Profuſely ſcatter'd o'er the blue immenſe.

THOMSON.

IN the view I have taken of the planetary ſyſtem, in my two preceding papers, what a magnificent idea of the Creator, and of his works, is preſented to the imagination! In the centre of the ſyſtem, is placed the ſun, a ſtupendous body of fire, around whoſe orb, the planets, ſatellites, and comets, perform their revolutions with a regularity, which muſt fill the mind with the moſt exalted conceptions of their Divine Original. Who can contemplate the magnitudes and diſtances of thoſe vaſt bodies, and the beautiful harmony of their motions, and not be ſtruck with the grandeur of the ſcene, and the wonders of Omnipotence? But what muſt be our aſtoniſhment, when we are told, that this glorious ſyſtem, is only a ſmall part of the univerſe; and that, if it were wholly annihilated, it would be no more miſſed, by an eye that could take in the whole creation, than a grain of ſand from the ſeaſhore.

To form ſome idea, however imperfect, of the extent of the univerſe, and the more glorious works

of creation, we muſt turn our attention to the ſtarry firmament: we muſt viſit thoſe numerous and ſplendid orbs, which are diſperſed throughout the heavens, far beyond the limits of our planetary ſyſtem.

It is in theſe higher regions, that the Almighty has diſplayed himſelf in ſuch indelible characters, as muſt rouſe the moſt inſenſible ſpectator, and fill his mind with admiration and aſtoniſhment. By contemplating the magnitudes and diſtances of the fixed ſtars, all partial conſiderations of high and low, great and ſmall, vaniſh from the mind; and we are preſented with ſuch an unbounded view of Nature, and the immenſity of the works of creation, as overpowers all our faculties, and makes us ready to exclaim with the Pſalmiſt, "Lord, what is man, that thou art mindful of him, or the ſon of man, that thou regardeſt him"?

The fixed ſtars are diſtinguiſhed from the planets by being brighter and more luminous, and by continually exhibiting that appearance, which we call the ſcintillation or twinkling of the ſtars. This, probably, ariſes from their appearing ſo extremely ſmall, that the interpoſition of any very minute ſubſtance, of which there are many conſtantly floating in the atmoſphere, deprives us of the ſight of them: but as the interpoſed body ſoon changes its place, we again ſee the ſtar; and this ſucceſſion being perpetual, occaſions the twinkling.

But a more remarkable property of the fixed ſtars, and that from which they obtain their name, is their never changing their ſituation with regard to each other, as the planets do: for, although the revolution of the earth upon its axis occaſions an apparent daily motion of the whole frame of the heavens, in a contrary direction, yet any two fixed ſtars being obſerved, at ſeveral diſtant intervals of time, will always be found to preſerve the ſame relative poſition during the whole of this revolution.

It is not to be imagined, that the ſtars are placed in one concave ſurface, ſo as to be all equally diſtant from us; but they are diſperſed through unlimited ſpace in ſuch a manner, that there may be as great a diſtance between any two neighbouring ſtars, as there is between our ſun and thoſe which are the neareſt to him: ſo that an obſerver, if placed near any fixed ſtar, would conſider that alone as a real ſun, and the reſt as ſo many ſhining points, placed at infinite diſtances from him in the firmament.

Thoſe ſtars are ſuppoſed to be the neareſt to us which ſeem the largeſt, and are called ſtars of the firſt magnitude; and ſo on as far as the ſixth; which includes all the ſtars that are viſible without a teleſcope. And though, in a clear winter's night, when the moon is below the horizon, the ſtars ſeem to be innumerable; yet, as the whole firmament is divided into conſtellations, the number which can be ſeen at once, by the naked eye, is not above a thouſand.

Since the invention of the teleſcope, indeed, the number of the ſtars has been conſidered as immenſe; becauſe, the more perfect our inſtruments are, the more ſtars appear: it is therefore probable, that no limits can be ſet to their number or diſtances.

The immenſe diſtance of the fixed ſtars from each other, and from our earth, is, of all conſiderations, the moſt proper for exalting our ideas of the works of God, and the extent of the creation. The ſtar neareſt to us, or the largeſt in appearance, is Sirius, or the Dogſtar. Now, the earth, in moving round the ſun, is 195,000,000 miles nearer to this ſtar in one part of its orbit, than in the oppoſite one; and yet the magnitude of the ſtar appears not to be in the leaſt altered or affected by it. The celebrated Huygens carried his thoughts ſo far upon this ſubject, as to believe that there might be ſtars at ſuch inconceivable diſtances from our earth, that their light, though it is known to travel at the rate of

10,000,000 miles in a minute, has not yet reached us ſince the creation of the world!

How diſtant ſome of the nocturnal ſuns!
So diſtant, ſays the ſage, 'twere not abſurd
To doubt, if beams, ſet out at Nature's birth,
Are yet arriv'd at this ſo foreign world;
Though nothing half ſo rapid as their flight.
An eye of awe and wonder let me roll,
And roll for ever. Who can ſatiate ſight
In ſuch a ſcene, in ſuch an ocean wide
Of deep aſtoniſhment? Where depth, heighth, breadth,
Are loſt in their extremes; and where to count
The thick-ſown glories in this field of fire,
Perhaps a ſeraph's computation fails. YOUNG.

The high-born ſoul
Diſdains to reſt her heaven-aſpiring wing
Beneath her native quarry. Tir'd of earth
And this diurnal ſcene, ſhe ſprings aloft
Through fields of air———————
She darts her ſwiftneſs up the long career
Of devious comets; through its burning ſigns
Exulting meaſures the perennial wheel
Of Nature, and looks back on all the ſtars,
Whoſe blended light, as with a milky zone,
Inveſts the orient. Now amaz'd ſhe views
The empyreal waſte, where happy ſpirits hold,
Beyond this concave heaven, their calm abode;
And fields of radiance, whoſe unfading light
Has travell'd the profound ſix thouſand years,
Nor yet arrives in ſight of mortal things. AKENSIDE.

The ſtars being at ſuch prodigious diſtances from the ſun, cannot poſſibly receive from him ſo ſtrong a light as they ſeem to poſſeſs, nor even a degree of brightneſs ſufficient to make them viſible to us: for his rays would be ſo ſcattered and diſſipated before they could reach ſuch remote objects, that they could never be tranſmitted back to our eyes, ſo as to render thoſe objects viſible by reflection. The ſtars

ſhine, therefore, by their own native and unborrowed luſtre, and are totally different from the planets, which are opaque bodies, without any other light than what they receive from the ſun.

Ten thouſand ſuns appear,
Of elder beam; which aſk no leave to ſhine
Of our terreſtrial ſtar, nor borrow light
From the proud regent of our ſcanty day. BARBAULD.

It is the opinion of the moſt enlightened philoſophers, that each of theſe fixed ſtars is a ſun, having worlds revolving round it, in the ſame manner as our earth and the planets revolve round our ſun. For it is not to be imagined, that the Almighty, who ever acts with infinite wiſdom, and does nothing in vain, ſhould have created ſo many glorious ſuns, adapted to ſo many important purpoſes, and placed them at ſuch diſtances from each other, without proper objects near enough to be benefited by their influence. To ſuppoſe that they were made only to give a faint glimmering light to the inhabitants of our globe, muſt beſpeak a very unworthy opinion of the divine Wiſdom; for many of the ſtars are ſo far from benefiting us, that they cannot be ſeen without the aid of a teleſcope; and the Deity, by an infinitely leſs exertion of creative power, could have given our earth far greater light by only one additional moon. To a ſuppoſition ſo unphiloſophical and abſurd, ſome of our poets very happily allude:

When I behold this goodly frame, this world
Of heaven and earth conſiſting, and compute
Their magnitudes, this earth, a ſpot, a grain,
An atom, with the firmament compar'd
And all her number'd ſtars, that ſeem to roll
Spaces incomprehenſible——————
————————merely to officiate light
Round this opacous earth, this punctual ſpot,
One day and night, in all their vaſt ſurvey

Uſeleſs beſide; reaſoning I oft admire,
How Nature, wiſe and frugal, could commit
Such diſproportions, with ſuperfluous hand
So many nobler bodies to create? MILTON.

Aſk for what end the heavenly bodies ſhine?
Earth for whoſe uſe? Pride anſwers, "is for mine:
——————— ſuns to light me riſe,
My footſtool earth, my canopy the ſkies". POPE.

But do theſe worlds diſplay their beams, or guide
Their orbs, to ſerve thy uſe, to pleaſe thy pride?
Thyſelf but duſt, thy ſtature but a ſpan,
A moment thy duration; fooliſh man!
As well may the minuteſt emmet ſay,
That Caucaſus was raiſed to pave his way:
The ſnail, that Lebanon's extended wood
Was deſtin'd only for his walk and food:
The vileſt cockle, gaping on the coaſt
That rounds the ample ſeas, as well may boaſt,
The craggy rock projects above the ſky,
That he in ſafety at its foot may lie;
And the whole ocean's confluent waters ſwell,
Only to quench his thirſt, or move and blanch his ſhell.
PRIOR.

Every ſtar then is the centre of a magnificent ſyſtem, attended by a retinue of worlds, irradiated by its beams, and revolving round it by its active influence. Thus the greatneſs of God is magnified, and the grandeur of his empire made manifeſt. He is not glorified on one earth, or in one world alone, but in ten thouſand times ten thouſand. "If we could wing our way to the higheſt apparent ſtar, we ſhould there ſee other ſkies expanded; other ſuns that diſtribute their inexhauſtible beams of day; other ſtars that gild the alternate night; and other (perhaps nobler) ſyſtems eſtabliſhed in unknown profuſion through the boundleſs dimenſions of ſpace. Nor does the dominion of the univerſal Sovereign terminate there: even at the end of this vaſt tour we

ſhall find ourſelves advanced no further than the ſuburbs of creation, the frontiers of the great Jehovah's kingdom".

This mode of reaſoning may be applied with greater force to the planets of our own ſyſtem, and gains ſtrength from other conſiderations. For who will preſume to aſſert, that Infinite Love and Conſummate Wiſdom have formed ſuch immenſe material maſſes (ſome of which greatly exceed our earth in ſize) convey them in revolutions round the ſun, provide them with moons, and grant them the alternate change of day and night, and the viciſſitudes of ſeaſons, and all this only to emit their ſcanty light on our earth?

Who, that has ſeen any engine, a windmill for inſtance, and knows the uſe of it, if he travels into another country, and there ſees an engine of the ſame ſort, will not reaſonably conclude, that it is deſigned for the ſame purpoſe? When, therefore, we know, that the uſe of this planet, the earth, is for the habitation of various animals, and we ſee other planets at a diſtance from us, ſome larger, and ſome ſmaller than our earth, moving round the ſun, revolving on their axes, and attended by moons; is it not reaſonable to conclude, that they are all deſigned for the ſame uſe as this earth is, and that they are habitable worlds, like the earth in which we reſide?

Who can perceive them "unpoſſeſſed
By living ſoul, deſert and deſolate,
Only to ſhine, yet ſcarce to contribute
Each orb a glimpſe of light"? MILTON.

Who can imagine that the omnipotent Creator, who has not left a ſingle drop of water unpeopled, and has filled every part of creation with animated exiſtence, ſhould leave ſuch immenſe bodies deſtitute of inhabitants? It is ſurely much more rational to ſuppoſe them the abodes of intelligent beings; of beings endowed with capacities of knowing, loving,

and adoring their Creator; provided and bleſſed with every object conducive to their happineſs; many of them, perhaps, in a far greater ſtate of purity than the inhabitants of our earth; in poſſeſſion of ſuperior degrees of bliſs; and placed in ſituations, which furniſh them with ſcenes of joy, equal to whatever poetry can paint, or religion promiſe; and all under the direction, indulgence, and protection of infinite wiſdom and goodneſs [a].

In a word, it ſeems evidently to be the deſign of divine Providence, by this viſible variety of worlds, to exalt our minds above this planetary globe, in ſearch of that omnipotent Being upon whom all Nature is dependent; and the Creator, no doubt, in this immenſe diſplay of his wiſdom and power, deſigned the amazing whole as the adequate object of each part, and as ſuch equally open on all ſides, to the penetrating progreſs of human minds; and through the moſt extenſive faculty of ſenſe, the ſight, to draw our reaſon and underſtanding, by degrees, from finite objects to infinite; from the contemplation of terreſtrial objects to the ultimate enjoyment of Himſelf in ſcenes of everlaſting bliſs:

For, from the birth
Of mortal man, the ſov'reign Maker ſaid,
That not in humble nor in brief delight,
Not in the fading echoes of Renown,
Power's purple robes, nor Pleaſure's flowery lap,
The ſoul ſhould find enjoyment: but from theſe
Turning diſdainful to an equal good,
Through all the aſcent of things enlarge her view,
Till every bound at length ſhould diſappear,
And Infinite Perfection cloſe the ſcene. AKENSIDE.

[a] See Young's Night Thoughts, vi, 174 to 190. ix, 1514 to 1532. Blackmore's Creation, ii, 526 to 542. Prior's Solomon, i, 502 to 535. Spectator, No, 420, 565.

X. ON THE FIGURE AND MOTION OF THE EARTH.

Qui tellurem medio libraverat axe.

CLAUDIAN.

The globe terreſtrial, with its ſlanting poles,
And all its ponderous load, unwearied rolls.

BLACKMORE.

FROM the contemplation of the ſtarry firmament, the infinite aſſemblage of worlds beyond worlds, and ſyſtems beyond ſyſtems, I now deſcend to a more particular conſideration of our terraqueous globe.

My ſoul, unus'd to ſtretch her powers
In flight ſo daring, drops her weary wing,
And ſeeks again the known accuſtom'd ſpot,
Dreſt up with ſun, and ſhade, and lawns, and ſtreams,
A manſion fair and ſpacious for its gueſt,
And full replete with wonders. BARBAULD.

This vaſt body was long conſidered as a circular plane, extending on all ſides to an infinite diſtance. The firmament above, in which all the heavenly bodies ſeem to move daily from eaſt to weſt, was ſuppoſed to be at no great diſtance from this earth, and to have been created ſolely for its uſe and ornament. But this opinion, retained only by the vulgar and uninformed, I have ſufficiently refuted in my preceding paper.—It is now received as an inconteſtible truth, that the earth is of a ſpherical figure, nearly reſembling that of a globe.

It is not neceſſary to enter into any ſcientific reſearches, in order to demonſtrate the truth of this doctrine. It is evident, from its having been frequently ſailed round. The firſt time was in the year 1519, when Ferdinand Magellan made a voyage

round the whole globe in 1124 days. In 1557, ſir Francis Drake performed the ſame in 1056 days; in 1586, ſir Thomas Cavendiſh made the ſame voyage in 777 days; Simon Cordes, of Rotterdam, in the year 1590; and in 1598, Oliver Noort, a Dutchman, in 1077 days; William Cornelius Van Schouten, in the year 1615, in 749 days; James Heremites and John Huygens, in the year 1623, in 802 days; and many others have ſince performed the ſame circumnavigation. All theſe intrepid navigators, by ſailing continually from eaſt to weſt, at length arrived in Europe, whence they had ſet out; and, in the courſe of their voyage, they obſerved all the phenomenons both of the heavens and the earth, to correſpond to this ſpherical figure.

Another evidence of this form is the circular appearance of the ſea itſelf, and the circumſtances which attend large objects when ſeen at a diſtance on its ſurface: for, when a ſhip is ſailing from the ſhore, we firſt loſe ſight of the hull, afterward of the rigging, and, at laſt, diſcern the top of the maſt only. This is evidently occaſioned by the convexity of the water between the eye and the object; for otherwiſe, the largeſt and moſt conſpicuous part would be viſible the longeſt.

Another proof is taken from the ſhadow of the earth, upon the face of the moon, in the time of an eclipſe: for, as the moon has no light but what it receives from the ſun, and the earth (during the eclipſe) is interpoſed between them, the moon muſt be obſcured, either totally, or in part. And ſince, in every lunar eclipſe, which is not total, the obſcure part always appears to be bounded by a circular line, the earth itſelf, for that reaſon, muſt be ſpherical; it being evident, that nothing but a ſpherical body can, in all ſituations, caſt a circular ſhadow.

The little unevenneſſes on the ſurface of the earth,

which are cauſed by mountains and vallies, afford no objection to its being conſidered as a circular body; for the loftieſt mountains bear leſs proportion to the vaſt magnitude of the earth, than the ſmall riſings on the coat of an orange bear to the orange itſelf, or a grain of ſand to an artificial globe of a foot diameter. And accordingly we find, that theſe trifling protuberances occaſion no irregularities in the ſhadow of the earth, during the time of a lunar eclipſe. On the contrary, its circumference appears invariably to be as even and regular as if caſt by a body perfectly globular.

This doctrine of the ſpherical figure of the earth is undoubtedly very ancient: for at the taking of Babylon by Alexander the great, eclipſes were found to have been computed for many ages before the birth of Chriſt; which could not have been done without a knowledge of the globular figure of the earth. And Thales, the Mileſian, who lived about 600 years before Chriſt, is ſaid, by Herodotus, to have predicted an eclipſe of the ſun, which ſhows that he was ſufficiently acquainted with the ſubject of eclipſes in general.—But it is alſo equally certain, that of this ſpherical figure of the earth, ſome of the greateſt men in thoſe times were ignorant. Heraclitus imagined it to have the ſhape of a canoe; Anaximander ſuppoſed it to be cylindrical; and Ariſtotle, the great oracle of antiquity, and even of later ages, gave it the form of a timbrel.

The vulgar opinion of the earth, that it was a flat body, infinitely extended, and covered by the ſky, in the form of a dome, continued to be the moſt univerſal, even ſo late as the fifteenth century. But a very little time before the diſcovery of America, the notion of the earth having a globular form was treated as an impious abſurdity, contrary to the opinion of the moſt venerable fathers of the church, and to

ſome expreſs declarations of the holy Scriptures [a]. The dictates of reaſon, however, with the voyage of Chriſtopher Columbus, reſtored to the earth the ſpherical figure, which the ancient Egyptians and Chaldeans had given it; and it was then generally believed to be a perfect globe, and that the ſtars made their revolutions round it in circular orbits.

Of this opinion were the greateſt philoſophers of the age. A globe is the moſt perfect of all geometrical figures; and the manifeſt ſimplicity of Nature in moſt of her operations, ſeemed to favour the idea of the earth having ſuch a form. This ſimplicity, however, appeared to be a falſe light, by which its followers were miſled.—M. Richer, in a voyage to Cayenne, near the equator, found that the pendulum of his clock no longer made its vibrations ſo frequently as in the latitude of Paris; and that it was abſolutely neceſſary to ſhorten it by a little more than the eleventh part of a Paris inch, to make it agree with the times of the ſtars paſſing the meridian.

Natural philoſophy and geometry were then very far from being ſo much cultivated as they are at preſent; and who could have believed, ſays Voltaire, that from an obſervation ſo trifling in appearance, ſuch a ſublime and philoſophical truth could ſpring?

[a] Theſe paſſages of ſcripture are either ill underſtood, or ſtrangely perverted from their real meaning. For it is evident, that the ſacred writers ſpeak every where according to the common appearances of things, and were not ſo ſolicitous to inſtruct us in philoſophy and aſtronomy, as to make us good men, by laying before us a plain rule of faith and conduct. Thus, when Joſhua ſpeaks of the ſun and moon ſtanding ſtill, and Job deſcribes the earth as being ſupported by pillars, they uſed the popular language of the times, without concerning themſelves with the ſtrict philoſophical propriety of the terms they employed; the one being a hiſtorical relation, and the other a dramatical compoſition, in which ſuch figures of ſpeech have been always allowed. And even now, the moſt philoſophical perſons, both in writing and converſation, ſpeak of the progreſs of the ſun, &c. in the popular way, according to the appearance of it, although contrary to the reality. Thus Thomſon:

> And now from Aries *rolls* the bounteous Sun,
> And the bright Bull receives him.

A pendulum, like any other falling body, is acted upon by the force of gravity, or the natural tendency of bodies toward their centre; and in conſequence of Richer's diſcovery, it was obſerved, that ſince the gravity of bodies is by ſo much the leſs powerful as thoſe bodies are further removed from the centre of the earth, the region of the equator muſt abſolutely be much more elevated than that of France; and, conſequently, the figure of the earth could not be that of a ſphere.

The obſervations made at Cayenne, might have been conſidered as too local and particular to admit of any ſatisfactory concluſion; but as a like alteration was found to take place by ſubſequent obſervations in many different ſituations, we can no longer heſitate to receive it as a general phenomenon, ariſing from an actual diminution of gravity, in thoſe places where the experiment was performed.

Newton and Huygens were the firſt who perceived the extenſive application of which this diſcovery was capable; and, by purſuing it through all its conſequences, they obtained the ſolution of a problem, which ſeemed beyond the reach of human abilities. This was no leſs than the determining of the true figure of the earth.

It is a known property of the pendulum, that all its vibrations are made in the ſame time; and that the time in which each vibration is performed, is in proportion to the ſquare root of the length of the rod: thus, a pendulum of thirty-ſix Paris inches in length, makes its vibrations in a ſecond; and one of nine inches makes its vibrations in half a ſecond; ſo that the ſhorter the pendulum, the more ſwiftly it moves; and the longer it is the more ſlowly it moves; the ratio being always the ſame as that before mentioned.

The time, therefore, in which any pendulum performs its oſcillations, depends as well upon the

length of that pendulum, as upon the force which impels it toward the ſurface of the earth. If this force be diminiſhed by any cauſe whatever, the body, with a leſs capacity for motion, will employ a longer ſpace of time to move through the ſame ſpace; and, in order that each vibration may be made in the ſame time that it was before this diminution took place, the length of the rod muſt be ſhortened, by which a new velocity will be given to it, that will be ſufficient to ſupply the defect; and this was exactly the caſe in all the experiments made near the equator.

Gravity, then, it is evident, is leſs powerful under the equator than in thoſe parts of the earth that lie near the poles. The limits of my paper will not permit me to enter into ſuch an illuſtration of this, as would be ſatisfactory to the philoſophical inquirer. I muſt be content, therefore, to obſerve, that there are two forces wh ch act in direct oppoſition to each other. The firſt, which is called the *centrifugal* force, is a certain tendency of bodies to fly off from the centre round which they move. This may be made evident, by obſerving the whirling of a mop, or the turning of a ſtone ſwiftly round in a ſling. The other force is called the *centripetal*. It is ſo called, becauſe it is directed toward the centre, and in the preſent caſe, is the ſame as *gravity*.—It is next to be conſidered, that the diurnal motion of the earth is performed round an imaginary line, which paſſes through the two poles; and according to ſir Iſaac Newton, as the equator is further diſtant from its centre, than any other circle which is parallel to it, it is plain, that thoſe parts of the earth which lie under the equator, will move with a greater velocity than thoſe which are nearer to the poles; and of courſe, the equatorial regions will become more elevated than the polar.—Now, as every part of the earth gravitates toward the centre, in conſequence of the centripetal force; and as this force is found to be

about 289 times greater than the centrifugal force, which ariſes from the rotation of the earth upon its axis, a certain balance will conſtantly be maintained between them, and the earth will aſſume ſuch a figure as would naturally reſult from the difference between theſe two contrary and oppoſite forces. Suppoſing, therefore, the primitive figure of the earth to have been that of a globe, which is the ſhape it would naturally aſſume from the action of the centripetal force, the oppoſite action of the centrifugal force muſt evidently change it into an oblate ſpheroid, or a body nearly reſembling a turnip or an orange. And this is the true figure of the earth as determined by ſir Iſaac Newton, who found by mathematical calculations, that the polar diameter of the earth is to the equatorial, as 229 is to 230; or that the regions of the equator are elevated about thirty-five miles more than thoſe at the poles.—This great mathematical truth is further confirmed by analogy; for it is eaſy to perceive, by a good teleſcope, that the planet Jupiter is flattened about his poles, in nearly the ſame manner as has been aſſerted of our earth; but as his rotation upon his axis is performed with a far greater rapidity than that of the earth, the alteration in his figure is found to be much more conſiderable; as would naturally follow from ſuch a motion. The relation of his diameters, according to Newton, is nearly as 12 to 13, and the difference between his equatorial and polar diameters is about 6230 miles.

I am now to conſider the motion of the earth; and in this diſcuſſion nothing more is neceſſary, than to obſerve the common appearances of the heavens. The ſun and ſtars, it is well known, ſeem to move daily from eaſt to weſt, and to return nearly to the ſame place in the heavens in twenty-four hours. It follows, therefore, that they muſt really move, as they appear to do, or elſe that we ourſelves muſt be moved; it being a ſelf-evident principle, that if the

ſituation of two bodies with reſpect to each other be changed, one of them, at leaſt, muſt be moved.

But if this change be owing to the revolution of the ſtars, we muſt ſuppoſe them to be endued with a motion ſo amazingly ſwift as to exceed all conception. Their diſtances from us are ſo immenſe, and the orbits they have to run round ſo prodigiouſly great, that the neareſt of them would move at leaſt 100,000 miles in a minute. Now, as Nature never does that in a complicated and laborious manner, which may be done in a more ſimple and eaſy way, it is more conſonant to reaſon, that theſe effects ſhould be produced by the motion of the earth; eſpecially, as ſuch a motion will beſt account for all the celeſtial appearances, and, at the ſame time, preſerve that beautiful ſimplicity and harmony, which is found to prevail in every other part of the creation. And it is much more probable, that the earth revolves round its axis, with an eaſy natural motion, once in twenty-four hours, than that ſuch ſtupendous bodies as the ſun and ſtars (the former above a million times bigger than the earth) ſhould be carried from one place to another with ſuch incredible velocity.

It is no objection to the rotation of the earth, that we are unable to perceive it; for, as the motion of a ſhip at ſea, when ſhe ſails ſwiftly over the ſmooth ſurface of the water, is almoſt imperceptible to the company on board; much more ſo muſt it be with ſuch a vaſt body as the earth, that can meet with no obſtacles to diſturb its motion. Milton obviates this objection, by repreſenting the earth advancing in her ſilent courſe,

With inoffenſive pace that ſpinning ſleeps
On her ſoft axle, while ſhe paces even,
And bears us ſoft with the ſmooth air along.

A balloon turning upon its axis as it floats through

the atmoſphere, affords a ſenſible repreſentation of the earth in its annual progreſs round the ſun, which is productive of the various viciſſitudes of the ſeaſons, winter, ſpring, ſummer, and autumn.

It has likewiſe been aſſerted, that if the earth moved, a ſtone dropped from the top of a tower, or any other high building, would not fall juſt at the bottom of it, as the building muſt have advanced conſiderably forward during the time of the fall. But it is well known, that if a body be projected from another body in motion, it will always partake of the motion of that other body. Thus, a ſtone dropped from the top of a maſt, while the ſhip is under ſail, is not left by the veſſel, but falls exactly at the foot of the maſt; for the atmoſphere, as Milton has obſerved above, is likewiſe bore along with the earth.

This motion of the earth round its axis is called its diurnal motion, and is that which occaſions the regular return of day and night, and all the celeſtial appearances beforementioned.—I could here deſcant with pleaſure on the various beneficial conſequences attending this daily revolution; but as this would lead my preſent diſquiſition too far, I ſhall conclude with the ſentiment of the Roman orator: "Diei noctiſque viciſſitudo conſervat animantes, tribuens aliud agendi tempus, aliud quieſcendi. Sic undique omne ratione concluditur, mente, conſilioque divino omnia in hoc mundo ad ſalutem omnium, conſervationemque admirabiliter adminiſtrari". And this reference of all things to the benevolent agency of the Supreme Being, is beautifully expreſſed by Mallet.

Thee, Nature's God!
Firſt ſource of all things lovely, all things good!—
Thee all things own! Thou ſpeak'ſt, and it is day.
Obedient to thy nod, alternate night
Obſcures the world. The ſeaſons at thy call
Succeed in train, and lead the year around.

XI. ON GRAVITY.

Thine theſe noble works,
Great, univerſal Ruler!
Thy virtual energy the frame of things
Pervading actuates; as at firſt thy hand
Diffus'd through endleſs ſpace this limpid ſky,
Vaſt ocean without ſtorm, where theſe huge globes
Sail undiſturb'd, a rounding voyage each;
Obſervant all of one unchanging law.
Simplicity divine! by this ſole rule,
The Maker's great eſtabliſhment, theſe worlds
Revolve harmonious, world attracting world
With mutual love, and to their central ſun
All gravitating. MALLET.

O, unprofuſe magnificence divine!
O, wiſdom truly perfect! thus to call
From a few cauſes ſuch a ſcheme of things,
Effects ſo various, beautiful, and great,
An univerſe complete. THOMSON.

MY late inquiries into the Solar Syſtem, the Plurality of Worlds, and the Figure and Motion of the Earth, naturally lead me to ſome conſiderations on Gravity, which is the moſt ancient and univerſal property of matter, and that, principally, by which the beauty, order, and harmony of the univerſe is invariably maintained. The illuſtrious Newton has purſued his ſpeculations on this ſubject with ſuch ſucceſs, that, the moſt ſimple nature of gravity being ſuppoſed, he has eſtabliſhed the true ſyſtem of the world beyond all controverſy, and explained clearly the moſt conſiderable phenomenons of Nature. And his opinion of the nature and properties of gravity is this:

Every ſingle particle of all bodies whatever, gravitates to every ſingle particle of all bodies whatever;

that is, they are impelled toward each other by the force of gravity.

This gravitating force is univerſal as to the *extent* of it; that is, all bodies whatever, ſo far as we know, wherever they are placed, not only on the earth, but alſo in the heavens, whether in the moon or planets, the ſun, or any other place, are endued with this power.

This force is alſo univerſal as to the *kinds* of bodies; that is, all bodies, whatever their figure, form, or texture be; whether they be ſimple or compound, ſolid or fluid; whether they be great or ſmall, in motion or at reſt; are endued with this power.

This force is alſo univerſal as to *time*; that is, all other conditions being the ſame, it never increaſes, nor diminiſhes.

The quantity of this gravity, at equal diſtances, is always exactly in proportion to the quantity of matter in the gravitating bodies: for inſtance, if a cubic foot of gold has a thouſand pound weight upon the ſuperficies of the earth, two cubic feet will have two thouſand pound weight upon the ſame ſuperficies; and if the earth contained but half the quantity of matter that it does now, the ſame cubic foot of gold, that has now a thouſand pound weight upon the ſuperficies of the earth, would have five hundred only.

The gravity of given bodies is greater or leſs, according to the diſtance of thoſe bodies from each other; for example, a ſtone which, near the ſuperficies of the earth, is very heavy, if it could be carried to a diſtance as high as the moon, would be very light.

And finally, the proportion of the increaſe or decreaſe of this gravity in bodies approaching to, or receding from, each other, is ſuch, that its force is reciprocally in a duplicate proportion, or as the ſquares of their diſtances: for example, a body which,

at the diſtance of ten diameters of the earth, weighs a hundred pounds, would, if its diſtance were but half as far, weigh four times as much; and if but a third part as far, nine times as much. In like manner, the force which, upon the ſuperficies of the earth, would ſupport a hundred pound weight, if it were twice as far off the centre, could ſupport four times the weight, and, if at three times as far off, could ſupport nine times the weight.

It muſt be obſerved, moreover, that the motion of falling bodies is increaſed in the proportion of odd numbers, 1, 3, 5, 7, 9, &c. ſo that the ſpaces they run through are as the ſquares of the times; that is, if a heavy body deſcend one foot in a ſecond of time, it will deſcend four feet in two ſeconds, nine feet in three ſeconds, &c.

Such are the principal properties of gravity, from the obſervation of which our immortal Newton deduced his ſublime theory of the univerſe. It may be pleaſing to the reader, to know the very ſimple incident, which, leading to the moſt extenſive and complicated calculations, was productive of the moſt noble and wonderful diſcoveries. It is thus related, on the authority of his friend and commentator, Dr. Pemberton:

Happening one day, in the year 1666, when only twenty-five years of age, to be ſitting under an apple tree, an apple falling upon his head, ſuggeſted a variety of reflections. The phenomenons of falling bodies, in particular engaged his attention; and, extending his reſearches to the heavens, he began to inveſtigate the nature of motion in general. Becauſe there is motion, he reaſoned, there muſt be a force that produces it. But what is this force? That a body, when left to itſelf, will fall to the ground, is known to the moſt ignorant; but if you aſk them the reaſon of its thus falling, they will think you either a fool or a madman. The circumſtance is too

common to excite their wonder, although it is ſo embarraſſing to philoſophers, that they think it almoſt inexplicable.

It is impoſſible to follow this great philoſopher through all his reaſonings; but we may recapitulate ſome of the principal phenomenons of this ſimple, yet wonderful, this obvious, yet myſterious law of nature.—If I take a ſtone, and let it drop from my hand, it falls immediately to the ground, and would fall ſtill further, if there were a hole in the earth, and nothing to prevent its paſſage. In like manner, when a ſtone, or any other ſubſtance is placed upon a table, it preſſes the table with the ſame force, by which it would fall to the ground, if left to itſelf: and when a body is ſuſpended at the end of a ſtring, the force that impels it downward, ſtretches the ſtring, and, if it be not ſufficiently ſtrong, will break it.

The cauſe of this falling propenſity in all bodies, whatever it be, is called Gravity, Gravitation, or Attraction; and when a ſubſtance is ſaid to be heavy, nothing more is meant, than the tendency which it has to fall to the ground, or the force with which it preſſes on any ſubſtance that ſupports it. The *weight* and *gravity* of a body, therefore, may be taken for the ſame thing; for both expreſs the force by which the body is impelled toward the earth.

The ancients were very imperfectly acquainted with this obvious property of bodies. They believed, that there were ſubſtances, ſuch as vapours and ſmoke, which from their light nature would aſcend. There is no foundation, however, for this opinion, nor for that of abſolute levity in general; for, in a ſpace void of air, all bodies whatever, ſmoke or a ſtone, a feather or a guinea, fall to the bottom in the ſame time. The diſtinction, therefore, between light and heavy bodies is merely relative; as they have all a ſimilar propenſity to fall to the earth.

The ſame body, conveyed to different places upon the ſurface of the earth, will not always have the ſame weight: for the weight of a body under the equator (as I demonſtrated in my laſt paper) is leſs than at either of the poles; and, in every other ſituation, it varies in a certain proportion to the latitude of the place.

The earth is a globe, and gravity acts perpetually in ſtraight lines, which are perpendicular to its ſurface. Suppoſe a hole could be bored through it, and that a body were placed at the centre, what would be its weight? Evidently nothing: it would remain in that ſituation, unſuſpended and unſupported. The force of gravity being conſtantly directed toward the centre, it could have no propenſity to move either way, and would, therefore, have no weight. For the ſame reaſon, if a body were thrown into this hole, from the ſurface of the earth, the velocity acquired by the repeated impulſes of gravity during the time of its fall, would carry it to the oppoſite extremity of the perforation, whence it would return, and continue to move backward and forward for ever, if the medium had no reſiſtance. Theſe two caſes may be illuſtrated by the pendulum of a clock, which, if once ſtopped would move no more, till put again into motion by ſome impelling force, when (ſuppoſing the conſtant action of the weight) it would continue its vibrations.

In applying his reflections on the nature of falling bodies to the celeſtial motions, Newton ſoon perceived, that the force of gravity was not confined to the ſurface of our globe; it being found to act alike at the bottom of the loweſt vallies, and at the ſummit of the moſt lofty mountains. This led him to conjecture, that it might extend as far as the moon, and be the means of retaining her in her orbit. Imagine the moon, he reaſoned, at the firſt moment of its creation, to have been projected forward, with a cer-

tain velocity, in a rectilinear direction; then, as ſoon as it began to move, gravity would act upon it, and impel it toward the centre of the earth. But as a body, impelled by two forces, will follow the direction of neither, the moon, ſo circumſtanced, would neither proceed directly forward, nor fall directly downward, but keep a middle courſe, and move round the earth in a curvilinear orbit.

This may be more fully illuſtrated, by attending to the motion of a ſhot, or any other projectile. A ball, ſhot from the mouth of a cannon, in a horizontal direction, does not fall to the ground till it has proceeded to a conſiderable diſtance; and if it be diſcharged from the top of a high mountain, it will fly ſtill further before it comes to the earth. Increaſe the force and the height, and the diſtance will be augmented accordingly. And thus, in imagination at leaſt, we can ſuppoſe the ball to be diſcharged with ſuch velocity, that it will never come to the ground, but return to the place whence it ſet out, and circulate continually round the earth, in the manner of a little moon.

Thus proceeding in his reflections, Newton diſcovered the admirable proviſion of the great Creator to prevent the evagation of the planets, and to retain them exactly within the bounds of their orbits. This he has demonſtrated to be effected by gravity, and that gravity and motion completely ſolve all the phenomenons of the planetary revolutions, both primary and ſecondary. By eſtabliſhing this one principle in philoſophy he has fully explained the ſyſtem of the world, ſo far as it relates to this globe, and to all the reſt of the planets that regard the ſun as their centre.

Such is the Newtonian ſyſtem of univerſal gravitation or attraction. But what is this principle, which gives life and motion to inanimate beings, and how does it act? The effects are viſible, but the

agent that produces them is hidden from our ſenſes. It eluded the ſearch of Newton himſelf: he that ſoared to the utmoſt regions of ſpace, and looked through nature with the eye of an eagle, was unable to diſcover it [a]. Indeed, he did not attempt to aſſign the cauſe; it not being his intention to engage himſelf in framing hypotheſes, but to explain the phenomenons by experiments only, and to raiſe his noble ſuperſtructure on them. And, therefore, although the facts themſelves, and the final cauſes, are evident, I will not preſume to ſay, how it can come to paſs, that bodies act at ſuch immenſe diſtances from one another; but would rather acquieſce in adoring the wiſdom and power of the great Author of all things, who has inſpirited the materials of which the univerſe conſiſts, with ſuch an active quality, as not only ſerves to preſerve the planets themſelves entire [b], but

[a] That there is, however, ſuch a principle, is not to be doubted. To deny its exiſtence, would be to deny the truth of facts, eſtabliſhed by experiment and demonſtration. That two diſtant bodies will approach toward each other, without any viſible agent, either attracting or impelling them, may be made manifeſt by various inſtances. The loadſtone and a piece of iron mutually attract each other: two cork balls, ſwimming in water, approach together, and meet; and, in electricity, we have numberleſs experiments to ſhow, that ſeveral other bodies have the like propenſity to unite and adhere to each other. Theſe bodies, it is true, act by particular laws, different from that of gravity; but they ſerve ſufficiently well to illuſtrate the nature of that principle. *Bonnycaſtle's Introduction to Aſtronomy, page* 119.

Theſe principles I conſider, not as occult qualities ſuppoſed to reſult from the ſpecific forms of things, but a general law of nature, by which the things themſelves are formed: their truth appearing to us by phenomenons, though their cauſes be not yet diſcovered. For theſe are manifeſt qualities, and their cauſes only are occult, &c. *Newt. Opt. p.* 374.

[b] Beſide the beneficial effects of gravity, in cauſing, by the lunar influence, the diurnal variations of the tides, we ſhall find, in another reſpect, how much this great law of nature is ſubſervient to the good, and even to the very exiſtence of our globe and all the planets; and that is, in the preſervation of their integrity againſt the effects of their diurnal revolutions. For, without ſuch a band as gravity to keep their parts entire, the whirling about of thoſe globes would ſhatter them to pieces, and ſcatter them into the circumambient ſpace. "Thus (ſays Dr. Derham) muſt it needs befall our own globe, which whirls about

to enable them to revolve about their luminous centers, in orbits at once the moſt convenient, invariable and permanent [a].

O Sun!
Soul of ſurrounding worlds! in whom beſt ſeen
Shines out THY MAKER———
'Tis by thy ſecret, ſtrong *attractive* force,
As with a chain indiſſoluble bound,
Thy ſyſtem rolls entire; from the far bourne
Of utmoſt [b] Saturn, wheeling wide his round
Of thirty years; to Mercury, whoſe diſk
Can ſcarce be caught by philoſophic eye,
Loſt in the near effulgence of thy blaze. THOMSON.

at the rate of above 1000 miles an hour, and is compoſed of earth and water, materials of much too looſe a texture to prevent the diſſipation, which the centrifugal force of ſuch a rotation muſt neceſſarily occaſion about the equatorial parts; a rotation that would as eaſily throw off the parts of the earth, eſpecially the waters, as the whirling round of a wheel or a globe would the looſe duſt and water lodged thereon. But by reaſon the gravitating power exceeds the centrifugal, as 2174 exceeds 7.54064, that is, above 288 times; therefore all parts lie quiet and ſecure in their reſpective places, and enjoy all the benefits which accompany this motion, without any diſturbance from it." *Aſtro-Theology*, b. vi. ch. 2 —He adds, that this is far more remarkable in the Sun, which revolves round its axis, at the rate of 4262 miles an hour; and of Jupiter, which, at its equator, revolves round at the hourly rate of 38,159 miles.

[a] Gravity, or the weight of bodies, is not any accidental effect of motion, or of any very ſubtile matter, but an original and general law of all matter, impreſſed upon it by God, and maintained in it perpetually by ſome efficient power, which penetrates the ſolid ſubſtance of it; for gravity never is in proportion to the ſuperficies of bodies, or of any corpuſcles, but always to the ſolid quantity of them. Wherefore we ought no more to inquire how bodies gravitate, than how bodies began firſt to be moved. *Dr. Clarke's Notes on Rohault*, part ii. ch. 28.

[b] The Georgian planet being then unknown.

XII. ON THE CLOUDS:

INCLUDING THE THEORY OF EVAPORATION.

Who can number the clouds in wiſdom? JOB.

Ye miſts and exhalations that now riſe
From hill or ſteaming lake, duſky or gray,
Ti'l the ſun paint your fleecy ſkirts with gold,
In honour to the world's Great Author riſe,
Whether to deck with clouds th' uncoloured ſky,
Or wet the thirſty earth with falling ſhowers,
Riſing or falling ſtill advance His praiſe. MILTON.

THE radiant orbs which adorn the night, are not the only objects above to attract the philoſophic eye. The firmament exhibits inexhauſtible ſubjects of contemplation in a vaſt variety of igneous, aërial, and aqueous meteors. The latter, which are compoſed of vapours, or watery particles variouſly ſeparated and condenſed by heat and cold, form the clouds, with all the phenomenons of rainbows, hail, ſnow, rain, dew, &c. [a].

The beautiful, and very often fantaſtic, appearances of the clouds have not eſcaped the obſervation of the poets.

Sometime, we ſee a cloud that 's dragoniſh;
A vapour, ſometime, like a bear or lion,
A tower'd citadel, a pendent rock,
A forked mountain, a blue promontory
With trees upon 't that nod unto the world,
And mock our eyes with air.———

[a] The igneous or fiery meteors are lightning, aurora borealis, ignis fatuus, draco volans, falling ſtars, and other fiery phenomenons: for an account of theſe ſee No. XLIX and LI—The aërial or airy meteors conſiſt of flatulent and ſpirituous exhalations; ſuch as winds, whirlwinds, and hurricanes; for which ſee No. II.

That which is now a horſe, even with a thought
The rack diſlimns, and makes it indiſtinct
As water is in water. SHAKSPEARE.

When firſt the ſun too powerful beams diſplays,
It draws up vapours which obſcure his rays:
But ev'n thoſe clouds at laſt adorn its way,
Reflect new glories, and augment the day. POPE.

The ſun has loſt his rage: his downward orb
Shoots nothing now but animating warmth,
And vital luſtre: that, with various ray,
Lights up the clouds, thoſe beauteous robes of heaven,
Inceſſant rolled into romantic ſhapes,
The dream of waking fancy! THOMSON.

A cloud is a collection of condenſed vapour, ſuſpended in the atmoſphere. In other words, a cloud is a congeries of watery particles, or veſiculæ, raiſed from the waters, or watery parts of the earth, by the ſolar, or ſubterraneous, or electrical fire. Theſe watery particles, at their firſt riſe from our globe, are too minute, and too much ſeparated by their mutual repulſion, to be perceived; but as they mount, meeting with a greater degree of cold, loſing their electricity, or by any proceſs employed by nature for this purpoſe, they are condenſed, and rendered opaque, by the reunion of their parts, ſo as to reflect light, and become viſible.

There are few ſubjects of philoſophical inveſtigation that have occaſioned a greater variety of opinions than the theory of evaporation [a]; the man-

[a] The terms *exhalation* and *vapour* are ordinarily uſed indifferently; but the more accurate writers diſtinguiſh them; appropriating the term *vapour* to the moiſt fumes raiſed from water and liquid bodies; and *exhalation* to the dry ones emitted from ſolid bodies; as earth, fire, minerals, ſulphurs, ſalts, &c. In this ſenſe, exhalations are dry ſubtile corpuſcles, or effluvia, looſened from hard terreſtrial bodies, either by the heat of the ſun, or the agitation of the air, or ſome other cauſe; and emitted upward to a certain height of the atmoſphere, where, mixing with the vapours, they help to conſtitute clouds, and return back in dews, miſts, rains, &c.

ner in which vapours are raiſed into clouds; or the aſcent of water in ſuch a fluid as air, between eight and nine hundred times lighter than itſelf, to different heights according to the different denſities of the air; in which caſe it muſt be ſpecifically lighter than the air through which it aſcends.

The Carteſian philoſophers, with Dr. Nieuwentyt, Dr. Halley, Dr. Deſaguliers, and others, have had recourſe, but upon different principles, to *heat*, as the ſole cauſe of evaporation. But it has been ſhown, that the evaporation of water is ſo far from depending on its being rarefied by heat, that it is carried on even while water is condenſed by the coldneſs of the air, for water is gradually condenſed by the cold till it freezes; and ſince it evaporates even when frozen into hard ice, it muſt alſo evaporate in all the leſs degrees of cold. Heat, therefore, does not ſeem to be the principal, much leſs the only cauſe of evaporation.

Other philoſophers have attempted to account for evaporation, on a different principle, namely, that of *ſolution*; and they have ſhown, from a variety of experiments, that what we call evaporation is nothing more than a gradual ſolution of water in air, produced and ſupported by the ſame means, or by attraction, heat, and motion, by which other ſolutions are effected. The idea of this hypotheſis appears to have been firſt ſtarted, in 1743, by abbé Nollet: it was afterward adopted and purſued by Dr. Franklin, M. le Roi, and others; and, in 1765, it was firſt eſtabliſhed as the true theory of evaporation, by Dr. Hamilton.

By ſolution, Dr. Hamilton underſtands, with other writers, ſuch an intimate union between the particles of a body and thoſe of a fluid, that the whole ſhall appear a homogenous maſs, as tranſparent as the fluid was before ſuch union, and ſhall continue ſo, until ſome external cauſe produces a change.

He conſiders the tranſparency of the fluid as the criterion of true ſolution, and that which diſtinguiſhes it from a mixture. He proceeds to ſhow, that there is a mutual attraction between the water and air, of the ſame kind with that which is obſerved between the particles of any two bodies, one of which diſſolves the other. All water contains a conſiderable quantity of air, which may be ſeparated from it; and as the air retains its elaſticity, we may reaſonably ſuppoſe, that it is prevented from eſcaping by the force of attraction, juſt as the particles of gold are ſuſpended in aqua regia, by their attraction toward the particles of that fluid. Moreover, water exhauſted of its air will again imbibe a certain quantity, gradually drawing it into its pores till it is ſaturated, juſt as a lump of ſugar draws water into its pores. Air, likewiſe, evidently contains a quantity of water, which will be drawn from it, even in its pureſt and drieſt ſtate, by dry ſalt of tartar, ſo that the ſalt will become entirely fluid; and yet, in this caſe, the air is perfectly tranſparent. There is alſo a remarkable ſimilarity between the properties of common ſolution and thoſe of evaporation. As ſalt, beginning to diſſolve in water, appears at firſt to thicken the water that ſurrounds it, and the ſolution of it to be promoted by agitation; ſo, in like manner, the air, that lies at reſt over water, appears thick, and loaded with aqueous particles; in which caſe the evaporation proceeds very ſlowly, but is greatly promoted by a current of freſh air paſſing over the exhaling ſurface.

When a lump of any ſalt is diſſolved in clear cold water, the water that is firſt ſaturated with it, will riſe, on agitation, in curled wreaths, through the other water, render it ſomewhat opaque, and give an apparent tremulous motion to an object ſeen through it, till by degrees the ſolution is complete, and the tranſparency of the water is reſtored: the

caſe is the ſame when any two fluids of different denſities that will incorporate, are mixed together; thus, ſmoke or ſteam, when it firſt riſes into the air, exhibits ſimilar appearances; and the vapour riſing in a hot day from moiſt ground will make the air, and any objects ſeen through it, appear to have a tremulous motion, which is ſtill more obſervable when a teleſcope is uſed, that magnifies the floating vapours. Moreover, heat, by expanding bodies, enlarging the pores, and leſſening the mutual coheſion of their particles, promotes, and cold, on the contrary, in ſome meaſure retards and checks both ſolution and evaporation. As very hot water diſſolves ſalt ſooner, and in a greater quantity than cold water, and when cooled, depoſits part of the ſalt after a ſtrong ſolution, which was before diſſolved; ſo water will evaporate faſter in warm than in cold air; and, therefore, the air is generally clearer in cold than in hot weather. Thus, the aqueous vapours ſuſpended in the air during the heat of the day, fall down at night, and form themſelves into drops of *dew*[a]; or if the night be very cold, appear next morning cryſtallized in a *hoar-froſt*. If a bottle of very cold liquor be expoſed to the warm air in a hot day, the air contiguous to it being cooled, will let go part of its water, which will form a dew on the outer ſurface of the glaſs. By an experiment ſimilar to this, M. le Roi was firſt led to conclude, that water is really diſſolved in air: for the ſame reaſon a dew is formed on the inſide of the windows of a warm room, which on their outſide are expoſed to the cold air: Again, the quantity of a body diſſolved, and of a fluid evaporated, depends, *cæteris paribus*, on the quantity of ſurface.

It is to be obſerved, that there is a ſtronger attraction or affinity between ſpirit of wine and air than between water and air; and it being known

[a] See Reflections on Dew, in No. XXIII.

that the ſpirit evaporates much faſter than the water, the evaporation of fluids ſeems to ariſe from an attractive force between their particles and thoſe of air. Finally, after diſſolving a body in any proper menſtruum, if another body which has a greater affinity to the menſtruum be added, this will be diſſolved, and the firſt will be precipitated; and, in the ſame manner, any fluid will let go the air which it contains, on the addition of another body to which it has a greater affinity than it has to the air: from which fact it may be inferred, that the air, imbibed by any fluid, is, properly ſpeaking, diſſolved in that fluid, and therefore, that any fluid which evaporates, or is imbibed by the air, is alſo, properly ſpeaking, diſſolved in the air.

Dr. Hamilton having thus evinced the agreement between ſolution and evaporation, concludes, that the latter is nothing more than a gradual ſolution of water in air, produced and promoted by attraction, heat, and motion, juſt as other ſolutions are effected.

In order to account for the aſcent of aqueous vapours into the atmoſphere, this ingenious writer obſerves, that the loweſt part of the air being preſſed by the weight of the upper againſt the ſurface of the water, and continually rubbed upon it by its motion, attracts and diſſolves thoſe particles with which it is in contact, and ſeparates them from the reſt of the water. And ſince the cauſe of ſolution, in this caſe, is the ſtronger attraction of the particles of water toward the air than toward each other, thoſe that are already diſſolved and taken up will be ſtill further raiſed by the attraction of the dry air which lies over them, and thus will diffuſe themſelves, riſing gradually higher and higher, and thereby leave the lower air not ſo much ſaturated, but that it will ſtill be able to diſſolve and take up freſh particles of water; which proceſs is greatly promoted by the motion of the wind. When the vapours are thus raiſed and

carried by the winds into the higher and colder parts of the atmoſphere, ſome of them will coaleſce into ſmall particles, which ſlightly attracting each other, and being intermixed with air, will form *clouds*; and theſe clouds will float at different heights, according to the quantity of vapour born up, and the degree of heat in the upper parts of the atmoſphere. The clouds, therefore, are generally higher in ſummer than in winter; and this effect of renovated warmth, on the departure of Winter, is thus deſcribed by Thomſon:

At laſt from Aries rolls the bounteous Sun,
And the bright Bull receives him: then no more
Th' expanſive atmoſphere is cramp'd with cold,
But full of life and vivifying ſoul,
Lifts the light clouds ſublime, and ſpreads them thin,
Fleecy and white, o'er all-ſurrounding heaven.

When the clouds are much increaſed by a continual addition of vapours, and their particles are driven cloſe together by the force of the winds, they will run into drops heavy enough to fall down in *rain*. If the clouds are frozen before their particles are gathered into drops, ſmall pieces of them being condenſed and made heavier by the cold, fall down in thick flakes of *ſnow* [a]. If the particles are formed into drops before they are frozen, they become *hail-ſtones*. When the air is replete with vapours, and a cold breeze ſprings up, which checks the ſolution of them, clouds are formed in the lower parts of the atmoſphere, and compoſe a *miſt* or *fog*, which uſually happens in a cold morning, and is diſperſed when the ſun has warmed the air, and made it capable of diſſolving theſe watery particles. Southerly winds generally bring rain, becauſe, being commonly warm and replete with aqueous vapours, they are cooled

[a] See an account of this curious, beautiful, and very uſeful phenomenon, in No. III.

by paſſing into a colder climate; and therefore part with ſome of them, and ſuffer them to precipitate in rain: whereas northerly winds, being cold, and acquiring heat by coming into a warm climate, are ready to diſſolve more vapour than they before contained; and therefore, by long continuance, they are dry and parching, and uſually attended with fair weather.

Changes of the air, with reſpect to its denſity or rarity, as well as its heat and cold, will produce contrary effects in the ſolution of water and the conſequent aſcent or fall of vapours. Several experiments prove, that air, when rarefied, cannot keep as much water diſſolved as it does in a more condenſed ſtate; and, therefore, when the atmoſphere is ſaturated with water, and changed from a denſer to a rarer ſtate, the higher and colder parts of it will let go ſome of the air before diſſolved, form new clouds, and diſpoſe them to fall in rain: but a change from a rarer to a denſer ſtate will ſtop the precipitation of the water, and enable the air to diſſolve, either in whole or in part, ſome of thoſe clouds which were formed before, and render their particles leſs apt to run into drops, and fall down in rain: on this account, we generally find, that the rarefied and condenſed ſtates of the atmoſphere are reſpectively attended with rain or fair weather.

Such is Dr. Hamilton's theory of evaporation, on the new principle of ſolution; which is not only the moſt plauſible, but now the moſt generally received. —I ſhall conclude this paper by obſerving, that the clouds are not only at times among the moſt pictureſque and pleaſing, but among the moſt uſeful phenomenons of Nature. This is manifeſt from the refreſhing ſhade which the clouds afford, particularly in the torrid zone. How obviouſly too do they contribute to the fertility of the earth, by the refreſhing dews and ſhowers, which they ſhed over all the

tribes of vegetation, which would otherwiſe languiſh and die with perpetual drought, but cheriſhed by theſe, now flouriſh with the brighteſt verdure, and in all the variety of Nature's tints; ſo that the Contemplative Philoſopher may with great propriety adopt the language of the Pſalmiſt, "Thou viſiteſt the earth and watereſt it—Thou makeſt it ſoft with ſhowers: thou bleſſeſt the ſpringing thereof—The little hills rejoice on every ſide: the paſtures are clothed with flocks: the vallies alſo are covered over with corn; they ſhout for joy; they alſo ſing"!

XIII. ON THE DIVINE WISDOM AND GOODNESS IN THE WONDERS OF THE AIR.

At nuſquam emicuit pia cura et mira poteſtas
Splendidior, quam quod tanta ille effinxerit arte
Aëra, qui ſemper vitæ ſpiramina nutrit. C*******.

But not alone in yon ſtupendous ſpheres
His power immenſe, his majeſty appears:
We view his kind, his life-preſerving care,
In all the wond'rous properties of air. L****.

AIR, in a general ſenſe, is that inviſible fluid ſurrounding our globe, on which depends not only animal but vegetable life; and which ſeems, in ſhort, to be one of the great agents employed by Nature, in carrying on her operations throughout the world.

Though the attention of philoſophers, in all ages, has been employed, in ſome meaſure, by inquiries concerning the nature of the atmoſphere, yet, till the year 1750, little more than the mere mechanical action of this fluid was diſcovered, with the exiſtence of ſome anomalous and permanently elaſtic vapours, whoſe properties and relations to the air we breathe

were almoſt entirely unknown. Since that time, however, the diſcoveries concerning the conſtituent parts of the atmoſphere itſelf, as well as the nature of the different permanently elaſtic fluids that go under the general name of *air*, have been ſo numerous and rapid, that they have at once raiſed the ſubject to the dignity of a ſcience, and now form, under the name of *aërology*, a very important part of the modern ſyſtem of natural philoſophy.

Theſe diſcoveries, indeed, have not been more intereſting to philoſophers, than uſeful to ſcience and beneficial to ſociety. Many perplexing proceſſes in chymiſtry have been explained in conſequence of them; ſeveral have been facilitated; and a number of new and uſeful ones have been introduced. The phenomenons attending metallic calcinations and reductions have been greatly elucidated. The knowledge of the uſe of the air in reſpiration; the method of aſcertaining its purity and fitneſs for that function; the inveſtigation of dephlogiſticated air; the method of impregnating water with fixed air; are all calculated to anſwer purpoſes of the higheſt utility. The medicinal properties of fixed air have been in a great meaſure aſcertained; and its antiſeptic qualities, in other reſpects, promiſe to be of conſiderable advantage. The method of aſcertaining the purity of the air of a place, and the manner of ventilating an apartment, are of great uſe to thoſe concerned in public buildings. In ſhort, there is perhaps no ſtation in life where ſome knowledge of this ſubject may not be of uſe; and yet, intereſting and important as are theſe diſcoveries, they were unknown, not to the ancients only, but to the Bacons, the Newtons, the Boyles, and other illuſtrious philoſophers of the 17th century[a].—A very minute and

[a] Even the late Dr. Goldſmith, whoſe Hiſtory of the Earth and animated Nature, was publiſhed in 1774, appears to have had no knowledge of any difference in the kinds of air, except what was known in

particular inquiry into this ſubject cannot be expected in the limits of a ſhort eſſay. Volumes have been written upon it, the invaluable acquiſitions of the moſt patient and laborious inveſtigation. To, theſe, therefore, and particularly to the Obſervations and Experiments of Dr. Prieſtley, I muſt refer my more curious and inquiſitive readers.

For many ages the air was ſuppoſed to be a ſimple and homogeneous fluid; its common operations to depend on its heat, cold, moiſture, or dryneſs; and any effects which could not be explained by theſe (ſuch as the appearance of peſtilential diſeaſes) were thought to be entirely ſupernatural, and the immediate effects of the divine Power. It was reſerved for Dr. Prieſtley, to make the great diſcovery concerning the nature of our atmoſphere; and to inform the world, that it is compoſed of two fluids; the one abſolutely noxious, and incapable of ſupporting animal life for a moment; the other extremely ſalutary, and capable of preſerving animals alive and healthy for a much longer time than the pureſt air we can meet with. The firſt of theſe is *phlogiſticated air*; that is, the combination of common air with *phlogiſton*, which, in chymiſtry, is defined to be the moſt pure and inflammable principle; a principle exiſting in different bodies in various degrees and modes of combination [a]. The other is called *dephlo-*

the time of Mr. Boyle; although the important diſcoveries of Hales, Prieſtley, Brownrigg, Black, Cavendiſh, &c. were then known to moſt philoſophers.

[a] The combination of *phlogiſton* with different kinds of air, and alſo with water, has been illuſtrated and evinced by a variety of experiments by Dr. Prieſtley. All the kinds of air, he ſays, that appear to be eſſentially diſtinct from each other, are *fixed air*, *acid*, and *alkaline*; becauſe theſe, and another principle, called *phlogiſton*, which he has not been able to exhibit in the form of air, and which has never yet been exhibited by itſelf in any form, ſeem to conſtitute all the kinds of air, with which he is acquainted. He has alſo ſhown how common air is depraved and rendered unfit for the purpoſes of reſpiration, combuſtion, &c. by mixing with the *phlogiſton* diſcharged from

giſticated air, which is no other than exceedingly pure atmoſpherical air, entirely free from thoſe heterogeneous vapours, which contaminate the air we commonly breathe. It has been found by experience, that animals will live much longer in this kind of air than in an equal quantity of common air; whence it is ſuppoſed, that the breathing of it muſt be much more healthy, and contribute to longevity much more than the common atmoſphere. Nor are there wanting ſome who attribute the longevity of the antediluvians to the great purity of the atmoſphere at that time; the whole maſs being afterward tainted by the deluge, in ſuch a manner, that it could never regain its former purity and ſalubrity. But all this is mere conjecture; and excepting the ſingle fact, that animals live much longer in a quantity of *dephlogiſticated* than of common air, there is no evidence that the former contributes more to longevity than the latter. Dr. Prieſtley even throws out a conjecture, that the uſe of *dephlogiſticated air* might perhaps wear out the ſyſtem much ſooner than common air, in the ſame manner as it conſumes fuel much faſter than common air. The great quantity, however, even of the pureſt air, which is requiſite to ſupport animal life, and the expence and trouble of the moſt ready methods of procuring it, have hitherto prevented any fair trial from being made. Yet philoſophers, conſidering the probability of this kind of air being ſalutary in many diſeaſes, have be-

the lungs of animals, from burning bodies, from calcined metals, from putrefying ſubſtances, &c. and in ſome caſes being ſaturated with it, ſo as thereby to become phlogiſticated. And as a variety of cauſes contributes to the releaſe and diſcharge of *phlogiſton* from bodies in which it is combined, and from which by certain proceſſes it is diſengaged, which by uniting with the air diminiſhes it, precipitates its *fixed air*, and renders it noxious, he has diſcovered that vegetating plants purify the air by imbibing its *phlogiſton*, and that the agitation of water is alſo conducive to the ſame beneficial purpoſe.

ſtowed ſome pains in attempting to find out methods of procuring it eaſily, and in a large quantity [a].

This important diſcovery by Dr. Prieſtley had been preceded by the diſcoveries of many other ingenious philoſophers. To lord Bacon is due the diſcovery of *artificial* or *factitious air* [b]; a term uſed by Mr. Boyle to expreſs what the more ancient chymiſts denominated *gas*, or *ſpirtus ſilveſtris*, and which is now more generally known by the name of *fixed air*. It comprehends all thoſe kinds of air, which are originally parts of ſome ſolid ſubſtance, and exiſt in an unelaſtic ſtate; but which, by various analytical proceſſes, are capable of being diſengaged, and recovering their elaſticity.

Sir Iſaac Newton diſcovered the true *permanent air* ariſing from fixed bodies by heat and fermentation, and diſtinguiſhable from vapour, which is only *apparent* or *tranſient air*.—Dr. Hales diſcovered the air abounding in the Pyrmont waters, to which he attributed their ſpirit and briſkneſs. He was the firſt likewiſe that produced the *nitrous air* from the Walton pyrites, by means of ſpirit of nitre; and to him our hoſpitals, priſons, and ſhips of war, owe the beneficial invention of ventilators.—Dr. Brownrigg diſcovered the quality of that air, which is of the *mephitic*, or deadly kind; ſuch as is found in damps, deep wells, caverns, and mines, and which is ſo often fatal to miners.—Dr. Black was the firſt who accurately inveſtigated the chymical nature and effects of that particular kind of *factitious air*, to which he gave the name of *fixable* or *fixed air*; which adheres to all calcareous earths and alkaline ſalts, with different degrees of force; and which may be ſeparated from theſe ſubſtances, and again combined with them.—Mr. Cavendiſh firſt diſcovered the *acid air*, produced from copper, by means of ſpirit of ſalt: it

a See Cavallo's Treatiſe on Air.

b Sir John Pringle's Diſcourſe on the different kinds of Air.

has a ſtrong affinity with phlogiſton; extracts it from other ſubſtances, ſuch as inflammable ſpirits, expreſſed oils, &c. and is thereby converted into *inflammable air*. Mr. Cavendiſh alſo diſcovered *inflammable air*, of the nature of that found in neglected privies, common ſewers, and chiefly in coal-pits, where it is called the *fire-damp*. This kind of air is ſurpriſingly light, being only the tenth part of the weight of common air, and therefore totally different from the *mephitic* [a], or *fixed air*, which is found to be heavier. The *inflammable air* is that by which all the aëroſtatic machines (the Montgolfiers excepted) have been filled: it may be produced in abundance from zink, iron, and tin, by diſſolving them in the diluted vitriolic acid, or ſpirit of ſea ſalt [b].

It is impoſſible to notice the numberleſs improvements on theſe important diſcoveries, in conſequence of many ſubſequent experiments and obſervations.—I ſhall, therefore, confine myſelf now to the conſideration of air, in the more popular and extenſive ſignification of the term.

The *common, atmoſpherical*, or *heterogeneous air*, is a coalition of corpuſcles of various kinds, which together form one fluid maſs, wherein we live and move, and which we are continually receiving and expelling by reſpiration. The whole aſſemblage of this makes what we call the *atmoſphere*. Where this air, or atmoſphere, terminates, there *ether* is ſup-

[a] The term *mephitic* is applied to *fixed air*, to that which is *inflammable*, and to many other kinds, ſince they are equally noxious when breathed by animals; but it is uſually appropriated to the former ſpecies of air.

[b] As *inflammable air* is ſpecifically *lighter* than common air, it occupies the *upper* parts of ſubterraneous places, and is called the *fire-damp*, becauſe it is liable to take fire, and to explode like gunpowder. The *mephitic*, or *fixed air*, on the contrary, being ſpecifically *heavier* than common air, is found at the *bottom* of pits: it extinguiſhes candles, &c. and kills animals that breathe it; and, on this account, has been called the *choke-damp*.

poſed to begin; which is diſtinguiſhed from the air, by it's not making any ſenſible refraction of the rays of light, as air does.—Air, in this popular ſenſe, is acknowledged by Boyle to be the moſt heterogeneous body in the univerſe. Beſide the matter of light or fire, which continually flows into it from the heavenly bodies, and probably the magnetic effluvia of the earth, whatever fire can volatilize is found in the air.—In a word, a late eminent author conſiders the atmoſphere as a large chymical veſſel, wherein the matter of all the kinds of ſublunary bodies is copiouſly floating; and thus expoſed to the continual action of that immenſe ſurface the ſun, whence proceed innumerable operations, ſublimations, ſeparations, compoſitions, digeſtions, fermentations, putrefactions, &c.

The component parts of our atmoſphere are indeed ſo various, and of ſuch heterogeneous natures, that they do not admit of any kind of definition or analyſis, one only excepted, namely, the *electric fluid*. This, we know, pervades the whole, but appears to be much more copious in the upper than in the lower atmoſpherical regions. To meaſure the abſolute quantity of this fluid, either in the atmoſphere, or any other ſubſtance, is impoſſible. All that we can know on this ſubject is, that the electric fluid pervades the atmoſphere; that it appears, as before obſerved, to be more abundant in the ſuperior than in the inferior regions; that it ſeems to be the immediate bond of connection between the atmoſphere and the water that is ſuſpended in it; and that by its various operations, hail, rain, ſnow, lightning, and various other kinds of meteors, are occaſioned.

Various attempts have been made to aſcertain the height to which the atmoſphere is extended all round the earth. Theſe commenced ſoon after it was diſcovered, by means of the Torricellian tube, that air is a gravitating ſubſtance. Thus it alſo became

known, that a column of air, whoſe baſe is a ſquare inch, and the height that of the whole atmoſphere, weighs fifteen pounds; and that the weight of air is to that of mercury as 1 to 10,800; whence it follows, that if the weight of the atmoſphere be ſufficient to raiſe a column of mercury to the height of thirty inches, the height of the aërial column muſt be 10,800 times as much, and conſequently a little more than five miles high.

It was not, however, at any time ſuppoſed, that this calculation could be juſt; for as the air is an elaſtic fluid, the upper parts muſt expand to an immenſe bulk, and thus render the barometrical calculations extremely erroneous. Philoſophers, therefore, have had recourſe to another method, in order to determine the height of the atmoſphere; namely, by a calculation of the height from which the light of the ſun is refracted, ſo as to become viſible to us before he himſelf is ſeen in the heavens. By this method it was determined, that, at the height of forty-five miles, the atmoſphere had no power of refraction; and, conſequently, beyond that diſtance, was either a mere vacuum, or the next thing to it, and not to be regarded.

This theory ſoon became very generally received; and the height of the atmoſphere was ſpoken of as familiarly as the height of a mountain, and reckoned to be as well aſcertained as the height of the greater part of mountains. But ſlow, progreſſive, and imperfect, muſt be the inquiries of the philoſopher into the great ſecrets of Nature: to the moſt intelligent and penetrating of human minds much muſt ever remain myſterious and inſcrutable; myſterious and inſcrutable too, perhaps, even to beings of a ſuperior order to man in the ſcale of creation.—To this ſuppoſed height of the atmoſphere very great objections (and objections that have never yet been removed) ariſe from the appearance of ſome meteors, like large

globes of fire, not unfrequently to be ſeen at vaſt heights above the earth. One of this kind appeared in March 1719, whoſe height Dr. Halley computed to be about 70 miles, its diameter upward of a mile and a half, and its velocity about 350 miles in a minute. There was alſo a remarkable one in 1783, whoſe diſtance from the earth, computed by Dr. Blagden, could not be leſs than 50 miles, its diameter not leſs than the former, and its velocity not leſs than 1000 miles in a minute. Theſe meteors were not only extremely bright, but were attended with exploſions. But how was flame to be ſupported, or ſound propagated, at a height where the air muſt be 300,000 times rarer than that we breathe? Appearances of this kind are, indeed, with great probability, attributed to electricity; but the difficulty is not thus removed. In a word, it appears that the abſolute height of the atmoſphere is not yet determined. The beginning and ending of twilight indeed ſhow, that the height at which the atmoſphere begins to refract the rays of the ſun, is about forty-five miles. But this, perhaps, may be only the height to which the aqueous vapours are carried: for it cannot be thought an unreaſonable ſuppoſition, that light is refracted only by means of the aqueous vapour contained in the atmoſphere; and that where this ceaſes, it is ſtill capable of ſupporting the *electric* fire at leaſt, as bright and as ſtrong as at the ſurface. That it does extend much higher is evident from the meteors already mentioned; for theſe are undoubtedly carried along with the atmoſphere; otherwiſe that of 1783, which was ſeen for about a minute, muſt have been left 1000 miles to the weſtward, by the earth flying out below it, in its annual courſe round the ſun.

XIV. ON THE MECHANICAL PROPERTIES AND EFFECTS OF THE AIR,

AND THE BENEFICIAL ENDS TO WHICH IT IS SUBSERVIENT.

Mundi pars eſt aër, et quidem neceſſaria: hic eſt enim qui cœlum terramque connectit. SENECA.

Ipſe aër nobiſcum videt, nobiſcum audit, nobiſcum ſonat, nihil enim eorum ſine eo fieri poteſt. CICERO.

IN my former paper, I took a curſory review of the principal modern diſcoveries reſpecting the different kinds of air; I ſtated the moſt generally received-opinions, in conſequence of the component parts of our atmoſphere [a]; and entered into ſome diſcuſſion of the height to which philoſophers have ſuppoſed it to extend. The mechanical properties and effects of this wonderful fluid, with the variety of beneficial ends to which it is ſubſervient, are ſubjects no leſs worthy of conſideration.

The moſt conſiderable properties of air are its fluidity, weight, and elaſticity.

That the air is a fluid is evident from the eaſy paſſage through it which it affords to bodies; as in the propagation of ſmells and other effluvia, and the eaſy conveyance it affords to ſounds. Theſe, and ſimilar effects, prove it to be a body, whoſe parts give way to any force impreſſed, and, in yielding, are eaſily moved among themſelves; which is the definition of a fluid. Beſides, it is certain, that no degree of cold has ever yet been produced, natural or artificial, ſtrong enough to deprive it of its fluidity.—The

[a] I am aware of the controverſy now ſubſiſting (1789) between Dr. Prieſtley and the French philoſophers, concerning the exiſtence of Phlogiſton. But this controverſy, and the new terms they are adopting, I cannot enter into. See a note inſerted, from Dr. Darwin, at the commencement of my paper, No. XVI, On the Nature of Water.

cauſe of this fluidity of the air is attributed, by ſome late philoſophers, to the fire intermixed with it; without which, they imagine, the atmoſphere would harden into a ſolid, impenetrable maſs.

The weight, or gravity of the air, was firſt diſcovered by Galileo; but the preſſure of the atmoſphere was obſerved by his diſciple Torricelli, and the variations of it, depending on different heights, by M. Paſcal. That the air is heavy follows from its being a body; weight being an eſſential property of matter. But we have many arguments to the ſame purpoſe from ſenſe and experiment: thus, the hand, applied to the orifice of a veſſel empty of air, ſoon feels the load of the incumbent atmoſphere. Glaſs veſſels, exhauſted of their air, are eaſily cruſhed to pieces by the weight of the external air. Two ſmall hollow ſegments of a ſphere, four inches in diameter, exactly fitting each other, being emptied of air, are preſſed together by a force equal to 188 pounds, by the weight of the ambient air; and that they are kept together by the preſſure of the air is evident, by ſuſpending them in an exhauſted receiver, when they will ſeparate of themſelves. Moreover, if a tube, cloſe at one end, be filled with mercury, and the other immerged in a baſin of the ſame fluid, and thus erected, the mercury in the tube will be ſuſpended at the height of about thirty inches above the ſurface of that in the baſin. The reaſon of this ſuſpenſion is, that the mercury in the tube cannot fall lower, without raiſing that in the baſin; which being preſſed upon by the weight of the incumbent atmoſphere, cannot give way, unleſs the weight of the mercury exceeds that of the air without it.—That this is the caſe is evident; becauſe, if the whole apparatus be included in the receiver of an air-pump, the mercury will fall in proportion as the air is exhauſted; and, on gradually letting in the air again, the mercury reaſcends to its former height.

This makes what is uſually called the Torricellian Experiment.

The gravity of air may be further demonſtrated, from the conſideration that it can actually be weighed. Its weight is continually varying, according to the different degrees of heat and cold, and the concurrence of other cauſes. Its weight to that of water has been differently eſtimated by philoſophers. Dr. Jurin thinks, that at a medium between heat and cold, when the barometer is thirty inches high, the proportion between the two fluids may be taken as 1 to 800; which agrees with the obſervation of Mr. Cavendiſh, the thermometer being at 50 degrees, and the barometer at 29 $\frac{3}{4}$ inches [a].

Air, then, being heavy and fluid, the laws of its gravitation, or preſſure, may be inferred to be the ſame as in other fluids; and, conſequently, its preſſure muſt be as its perpendicular altitude. This is alſo confirmed by experiment: for, if the Torricellian tube be removed to a more elevated place, where the incumbent column of air is ſhorter, a proportionably ſhorter column of mercury is ſuſtained. On this principle depend the ſtructure and office of the barometer.

It follows hence, alſo, that the air, like all other fluids, muſt preſs equally every way. This is confirmed by obſerving, that ſoft bodies ſuſtain this preſſure without any change of figure, and brittle bodies without breaking; although the preſſure upon them is equal to that of a column of mercury thirty inches high, or a column of water, of thirty two feet. It is obvious, that no other cauſe can preſerve ſuch bodies unchanged, but the equable preſſure on all ſides, which reſiſts as much as it is reſiſted. And hence, upon removing or diminiſhing the preſſure on one ſide only, the effect of the preſſure is ſoon perceived on the other.

[a] Phil. Tranſ. vol. lvi, page 152.

From this gravity of the air, conſidered in connection with its fluidity, may be deduced ſeveral of its uſes and effects.—And firſt, by means of the weight and fluidity of the air, it cloſely inveſts the earth, with all the bodies upon it, and conſtringes and binds them down with a force amounting, according to the computation of M. Paſcal, to 2232 pounds weight upon every ſquare foot, or upward of 15 pounds upon every ſquare inch. Hence it prevents, for inſtance, the arterial veſſels of plants and animals from being too much diſtended by the impetus of the circulating juices, or by the elaſtic force of the air ſo plentifully contained in the blood.—Thus we ſee, in the operation of cupping, that, upon a diminution of the preſſure of the air, the parts of the body grow tumid; which neceſſarily alters the manner of the circulation through the capillaries, &c.—The ſame cauſe prevents the juices oozing and eſcaping through the pores of their containing veſſels.

The weight of the air likewiſe promotes the mixture of contiguous fluid bodies. Hence many liquids, as oils and ſalt, which readily and ſpontaneouſly mix in air, remain, on a removal of it, in a ſtate of ſeparation.—The gravity of air, moreover, in ſome caſes, determines the action of one body upon another; and, to the ſame principle are chiefly owing our winds, which are only air put in motion by ſome alteration in its equilibrium.

Elaſticity, the third property of the air which I have mentioned, is the power of yielding to an impreſſion by contracting its dimenſions; and, upon removing or diminiſhing the impreſſive cauſe, of returning to its former ſpace or figure. This elaſtic force has been long accounted the diſtinguiſhing property of air; the other properties, hitherto enumerated, being common to it with other fluids [a]. This

[a] From ſome late experiments, however, it is more than probable,

property of air was firſt diſcovered by ſome experiments of lord Bacon, who, upon this principle, conſtructed his *vitrum calendare*, the firſt thermometer.

Of this elaſtic power we have numerous proofs: thus, a blown bladder being ſqueezed in the hand, we find the incloſed air ſenſibly reſiſt; ſo that, upon ceaſing to compreſs, the cavities, or impreſſions, made in its ſurface, are readily expanded, and filled up again.—On this property of elaſticity depend the ſtructure and office of the air-pump.

Every particle of air always exerts this endeavour to expand, and thus ſtrives againſt an equal endeavour of the ambient particles; and when the reſiſtance of the latter happens, by any means, to be weakened, it immediately diffuſes into an immenſe extent. Hence it is, that thin glaſs bubbles, or bladders, filled with air, and exactly cloſed, being included in the exhauſted receiver of an air-pump, burſt, by the force of the included air. In like manner, a bladder, quite flaccid, containing the ſmalleſt quantity of air, ſwells in the receiver, and appears quite full. The ſame effect is alſo found, by carrying the flaccid bladder to the top of a high mountain.

The compreſſion of the air by its own weight is ſurpriſingly great; and it may be ſtill further compreſſed by art. The utmoſt limits to which air, of the denſity which it poſſeſſes at the ſurface of the earth, may be compreſſed, have not been aſcertained. Dr. Halley thinks, that no force whatever is able to reduce air into 800 times leſs ſpace than that which it naturally poſſeſſes on the ſurface of the earth [a]. On the contrary, M. Amontons, in the Memoirs of the

that the capacity of being compreſſed and expanded is not peculiar to air. Mr. Canton, in particular, infers, from ſeveral experiments, that ſpirit of wine, oil of olives, water, and mercury, are not only compreſſible, but elaſtic. *See Phil. Tranſ. vol.* lii. *art.* 103, *and vol.* liv. *art.* 47.

[a] Philoſ. Tranſ. Abridg. vol. ii. page 17.

French Academy, maintains, that there is no affixing any bounds to its condenſation; that greater and greater weights will ſtill reduce it into leſs and leſs compaſs; that it is elaſtic in virtue only of the fire which it contains; and that as it is impoſſible ever abſolutely to drive all the fire out of it, it is impoſſible ever to make the utmoſt condenſation.

The dilation of the air by virtue of its elaſtic force, is alſo found to be very ſurpriſing. Sir Iſaac Newton thinks it capable of diffuſing into above a million of times more ſpace than it before poſſeſſed [a], and Dr. Wallis ſuggeſts, that we are far from knowing the utmoſt of which it is capable.—This immenſe compreſſion and dilitation, ſir Iſaac Newton obſerves, cannot be accounted for in any other way, than by a repelling force, with which the particles of air are endued; by virtue of which, when at liberty, they naturally fly each other; and this repelling power, he adds, is ſtronger and more ſenſible in air than in other bodies.

This elaſtic power of the air is the ſecond great ſource of the effects of this important fluid. By means of this, it inſinuates into the pores of bodies, poſſeſſing this prodigious faculty of expanding, which is ſo eaſily excited, that it muſt neceſſarily put the particles of bodies, into which it inſinuates, into perpetual oſcillations. Indeed, the degree of heat, and the gravity and denſity of the air, and conſequently its elaſticity and expanſion, never remaining the ſame for the leaſt ſpace of time, there muſt be an inceſſant vibration, or dilatation and contraction, in all bodies.—We obſerve this reciprocation in ſeveral inſtances, particularly in plants, the *trocheæ*, or air-veſſels of which do the office of lungs; for the contained air alternately contracting and expanding, as the heat increaſes or diminiſhes, by turns preſſes the veſſels, and eaſes them again; and thus promotes

[a] Optics, page 371.

the aſcent and deſcent of their juices. Hence, we find that no vegetation or germination will proceed *in vacuo*. Beans, indeed, have been obſerved to grow a little tumid therein; and this has led ſome to attribute that to vegetation, which was really owing to no other cauſe than the dilatation of the air within them.

The air is very inſtrumental in the production and growth of vegetables, not only by invigorating their ſeveral juices, while in an elaſtic active ſtate, but alſo by greatly contributing, in a fixed ſtate, to the union and firm connection of their ſeveral conſtituent parts.

From this elaſtic force it is, that the air contained in bubbles of ice, by its continual action, burſts the ice; and thus glaſſes and other veſſels frequently crack, when their contained liquors are frozen. Thus alſo, entire columns of marble ſometimes cleave in the winter time, from the increaſed elaſticity of ſome little bubble of included air. From the ſame principle ariſe all putrefaction and fermentation, neither of which will proceed, even in the beſt diſpoſed ſubjects, *in vacuo*.

Air, moreover, not only acts by its common properties of gravity and elaſticity, but there are numerous other effects, ariſing from the peculiar ingredients of which it conſiſts.—It not only diſſolves and attenuates bodies by its preſſure and attrition, but as a *chaos* containing all kind of menſtrua, and conſequently poſſeſſing powers for diſſolving all bodies. Iron and copper readily diſſolve, and become ruſty in air, unleſs well defended with oil. Boerhaave aſſerts, that he had ſeen pillars of iron ſo reduced by air, that they might be crumbled to duſt between the fingers. Copper is converted by the air into a ſubſtance much like the verdigriſe produced by vinegar. Mr. Boyle relates, that, in the ſouthern Engliſh colonies, the great guns ruſt ſo faſt, that, after

lying in the air a few years, large cakes of *crocus martis* may be ſeparated from them. Acoſta adds, that in Peru the air diſſolves lead, and conſiderably increaſes its weight. Yet gold is generally eſteemed indiſſoluble by air; being never found to contract ruſt, though expoſed to it ever ſo long.—Stones, alſo, undergo the changes incident to metals.

Air, likewiſe, as I have obſerved in a former paper[a], by means of its diſſolving power, accelerates evaporation and diſtillation. It volatilizes fixed bodies; fixes volatile bodies; and brings many quieſcent bodies into action, by exciting their latent powers. In a word, in the various operations of chymiſtry, it is a very neceſſary and important agent; the reſult of particular proceſſes depending on its preſence or abſence, on its being open or incloſed.

Great part of the effects of air, which I have enumerated, were quite unknown, as ſuch, to the ancients. They conſidered it, however (as appears from the mottos at the head of this paper) as an eſſential part of the world, as connecting heaven and earth, and the only medium by which objects can be viſible to us, and ſounds become audible.—"If we conſider (ſays Dr. Derham) the nature and make of the air, we find it a maſs of ſubtile penetrating matter, fit to pervade other bodies; to penetrate into the inmoſt receſſes of nature; to excite, animate, and ſpiritualize; and, in ſhort, to be the very ſoul of this lower world; uſeful to the life, the health, the comfort, the pleaſure, and the buſineſs of the whole globe".—It is eſſential to the exiſtence of all creatures.

Were once the energy of air deni'd,
The heart would ceaſe to pour its purple tide;
The purple tide forget its wonted play,
Nor back again purſue its curious way.

[a] No. XII, containing the Theory of Evaporation.

To the motion and conveyance of many animals it is alſo neceſſary.

The feather'd warbler hence, with rapid wings,
Born through aërial fields, exulting, ſings.
With eaſe through all the fluid region ſtrays,
And charms the ſkies with his melodious lays.

Various ſorts of fiſh too are enabled to ſuſtain themſelves in any depth of water, and to riſe or ſink at pleaſure, by means of a kind of *veſicula*, or air-bladder which is found in their bodies [a].

Our atmoſphere is of admirable uſe in the enlightening of the world, by reflecting the heavenly bodies to us, and refracting the ſun beams to our eye; ſo that the day is protracted throughout the whole globe; the long and diſmal nights are ſhortened in the frigid zones; and day approaches them ſooner. The ſun itſelf riſes in appearance, when, in reality, it is abſent from them, to the great comfort of thoſe dreary regions.

It is in the atmoſphere that are aſſembled the clouds, which aſſume ſuch a variety of hues and forms, and which, as they are condenſed or rarefied, retain the vapours, or return them to the earth in rain, or hail, or ſnow.

The ſtreams, their beds forſaking, upward move,
And form again in wand'ring clouds above:
Hence rich deſcending ſhowers, hence balmy dews,
Their plenteous ſweets o'er bright'ning fields effuſe;
Hence ſhoots the graſs, the garden ſmiles with flowers,
And ſportive gales ſteal fragrance from the bowers.

In a former paper [b], I have given a philoſophical account of the winds, which are another important

[a] If this air-bladder be pricked or broken, the fiſh preſently ſinks to the bottom, unable either to ſupport or raiſe itſelf up again. Flat fiſh, as ſoles, plaiſe, &c. which always lie groveling at the bottom, have no air-bladder.

[b] See No. 11.

part of the ſubject of air. To that paper I refer my readers, and ſhall conclude my preſent eſſay with a poetical enumeration of their benefits:

Of what important uſe to human kind,
To what great ends ſubſervient is the wind!
Where'er th' aërial active vapour flies,
It drives the clouds, and ventulates the ſkies;
Sweeps from the earth infection's noxious train,
And ſwells to wholeſome rage the ſluggiſh main.
For ſhould the ſea unagitated ſtand,
Death, with huge ſtrides, would deſolate the land;
The ſcorching ſun, with unpropitious beam,
Would give to grief an everlaſting theme;
And baneful vapours, lurking in the veins,
Would fiercely burn with unabating pains.
Nor thus alone air purifies the ſeas,
O'er torrid climes it pours the healthful breeze:
Climes, where the ſun direct flings ſcorching day,
Feel cooling air his ſultry rage allay.
Unceaſing Goodneſs, with Unceaſing Skill,
Educing certain good from ſeeming ill,
His guardian care extend o'er every ſhore,
And blends his favours with what men deplore.
The ſable nations hence, and burning ſkies,
See luſcious fruits, in varying beauty riſe;
Spontaneous Nature laugh at Culture's toil,
And rich Luxuriance bleſs the grateful ſoil.

XV. ON THE INFLUENCE OF AIR ON VEGETATION, AND OF VEGETATION ON AIR.

I cannot go
Where Univerſal Love not ſmiles around—
From ſeeming Evil ſtill educing Good,
And better thence again, and better ſtill,
In infinite progreſſion. THOMSON.

I OBSERVED, in my preceding paper, that air is very inſtrumental in the production and growth of

vegetables. All vegetable bodies are provided with certain canals, or ducts, whereby a kind of reſpiration is effected in them. Theſe canals, which are called air-veſſels, are diſtinguiſhed from another wiſe contrivance of Nature—the ſap-veſſels. The former anſwer to the *tracheæ* and lungs of animals; the latter to their lacteals and blood-veſſels.

An ingenious natural philoſopher, in an inquiry into the motion and cauſe of the air in vegetables, has ſhown that it enters them various ways, not only by the trunk, leaves, and other parts above ground, but at the root. For the reception, as well as expulſion of air, the pores are ſo very large in the trunks of ſome plants (as in the better ſort of thick walking canes) that they are viſible to a good eye without a glaſs; but, with a glaſs, the cane ſeems as if it were ſtuck full of large pin-holes, reſembling the pores of the ſkin at the ends of the fingers, and ball of the hand. In the leaves of the pine, ſeen through a glaſs, they make an elegant appearance, ſtanding almoſt in rank and file, throughout the length of the leaves.

But although the air enters in part at the trunk and other parts, eſpecially in ſome plants, yet its chief admiſſion is at the roots; as in animals, ſome part of it may continually paſs into the body and blood by the pores of the ſkin; but the chief draught is at the mouth.

Air-veſſels are found in the leaves of all plants, and are even diſcoverable in many without the help of glaſſes; for, upon breaking the ſtalk or chief fibres of a leaf, the likeneſs of a fine woolly ſubſtance, or rather of curious ſmall cobwebs, may be ſeen to hang at both the broken ends. This is taken notice of only in ſome few plants, as in *ſcabious*, where it is more viſible; but it may be alſo ſeen, more or leſs, in moſt others, if the leaves be very tenderly broken. This wool is really a ſkain of air-veſſels,

or rather of the fibres of the air-veſſels, looſed from their ſpiral poſition, and ſo drawn out in length [a].

Dr. Hales, in his Statical Eſſays, has fully proved, that air is inſpired by vegetables; and he has ſhown, in many inſtances, that it freely enters into the veſſels of trees, and that it is wrought, in great abundance, into their ſubſtance. The ſubſtances of vegetables, he has obſerved, appear, by a chymical analyſis, to be compoſed of ſulphur, volatile ſalt, water, and earth, which are all endued with mutually attracting powers; and alſo of a large portion of air, which has a wonderful power of ſtrongly attracting, in a fixed ſtate, or of repelling in an elaſtic ſtate, with a power which is ſuperior to great compreſſive forces. By the infinite combinations, action, and reaction of theſe principles, all the operations in animal and vegetable bodies are effected. Theſe active aërial principles are very ſerviceable in carrying on the work of vegetation to its perfection and maturity; not only in helping, by their elaſticity, to diſtend each ductile part, but alſo by enlivening and invigorating their ſap, where, mixing with the other mutually attracting principles, they are by gentle heat and motion ſet at liberty to aſſimilate into the nouriſhment of the reſpective parts. The ſum of the attracting powers of theſe mutually acting and reacting principles, is, while in this nutritive ſtate, ſuperior to their repelling power; by which the work of nutrition is gradually advanced by the nearer and nearer union of theſe principles from a leſs to a greater degree of conſiſtency, till they are advanced to that viſcid ductile ſtate, whence the ſeveral parts of vegetables are formed; and are at length firmly compacted into hard ſubſtances, by the flying off of the watery diluting vehicle: but when they are again diſunited by the watery particles, their repelling power is thereby become ſupe-

[a] Dr. Grew, Anat. of Root, cap. iv. p. 155.

rior to their attracting power, and the union of the parts of vegetables is ſo thoroughly diſſolved, that putrefaction commences. And further, with reſpect to the nutrition of plants (which, in this paper, I can only mention in a curſory way) that celebrated anatomiſt and natural philoſopher, Dr. Hunter, has inferred, from a number of experiments, that all vegetables receive their principal nouriſhment from oily particles incorporated with water by means of an alkaline ſalt, or abſorbent earth; and to this univerſal principle of oil, he adds another of great efficacy, which is the nitrous acid of the air; a principle, the exiſtence of which is demonſtrable from the method of making ſaltpetre in different parts of the world.—It has likewiſe been obſerved, that the vegetables which have a ſucculent leaf, ſuch as vetches, peas, beans, and buck-wheat, draw a great part of their nouriſhment from the air [a].

Having thus conſidered the influence of air on vegetation, I ſhall now proceed to inquire into the influence of vegetation upon air.—Dr. Hales had produced a ſpecies of air, called *nitrous* air, from the Walton pyrites, by means of the ſpirit of nitre; but Dr. Prieſtley, by extending the experiment, found that the ſame kind of air might be procured, by means of the ſame kind of acid, from almoſt every other metallic ſubſtance; and that, when mixed with common air, an effervescence, with a turbid red colour, always enſued; and yet it made no change when either mixed with inflammable air, or tainted with the breath of animals, or the corruption of their bodies. By this criterion, he could judge of the kind, as well as the degree of injury done to common air, by candles burning in it, or by the breath of people after they had left him in his ſtudy. This diſcovery was attended with many important conſequences:

[a] See Hales' Statics; Hunter's Georgical Eſſays; and Contemplative Philoſopher, No. XXVIII and XXIX.

it diſplayed the reſources which Nature has in ſtore againſt the bad effects of corrupted air; in a word, it evinced, that one of her grand reſtoratives was vegetation.

It is well known that flame cannot long ſubſiſt without a renewal of common air. The quantity of that fluid which even a ſmall flame requires, is ſurpriſing: an ordinary candle *conſumes*, as it is called, about a gallon of air in a minute. Now, conſidering the vaſt conſumption of this vital fluid, by fires of all kinds made by man, and by volcanos, it becomes an intereſting inquiry to aſcertain what change is made in the air by flame, and to diſcover what proviſion there is in nature, to repair the injury to our atmoſphere, of which this change is productive. It will be proper, therefore, to ſtate by what inductions Dr. Prieſtley has proved his opinion.

It was natural to imagine, that, ſince the change of common air is neceſſary to vegetable, as well as to animal life, both plants and animals rendered it foul in the ſame manner, ſo as to become unfit for further life and vegetation. But when, with that expectation, the doctor had put a ſprig of mint, in a growing and vigorous ſtate, under an inverted glaſs jar, ſtanding in water, he was agreeably ſurpriſed to find, that this plant not only continued to live, though in a languiſhing way, for two months, but that the confined air was ſo little corrupted by what had iſſued from the mint, that it would neither extinguiſh a candle, nor kill a ſmall animal which he conveyed into it. The ſalutary nature of the effluvia of vegetables was further evinced by the obſervation, that air, vitiated by a candle left in it till it burnt out, was perfectly reſtored to its quality of ſupporting flame, after another ſprig of mint had for ſome time vegetated in it. And, to ſhow that the aromatic nature of that plant had no ſhare in reſtoring this purity to the air, he obſerved, that vegetables of an offenſive ſmell, and

even ſuch as had ſcarce any ſmell at all, but were of a quick growth, proved the very beſt for this purpoſe. In a word, the virtue of growing vegetables was found to be an antidote to the baneful quality of air corrupted by animal reſpiration and putrefaction.

This important diſcovery, that ſprigs of mint could thrive in a very ſurpriſing manner, even in air that had been freſhly and ſtrongly tainted with putrefaction, and that was immediately fatal to animal life, led the doctor to conclude, that plants, inſtead of affecting the air in the ſame manner with animal reſpiration, reverſe the effects of breathing, and tend to keep the atmoſphere ſweet and wholeſome, when it is become noxious in conſequence of animals either living and breathing, or dying and putrefying in it. And from various experiments he reaſoned thus: Since the plants made uſe of manifeſtly grow and thrive in putrid air; ſince putrid matter is well known to afford proper nouriſhment for the roots of plants; and ſince it is likewiſe certain that they receive nouriſhment by their *leaves* as well as by their roots, it ſeems to be very probable, that the putrid effluvium is in ſome meaſure extracted from the air, by means of the leaves of plants; and, therefore, that they render the remainder more fit for reſpiration.—Having thus aſcertained the fact, that vitiated air was reſtored by vegetation, and conſidered that common air is vitiated by being combined in various ways with phlogiſton, he was led to conjecture, that this reſtoration was effected by plants imbibing the phlogiſtic matter with which air is loaded by any of thoſe proceſſes that tend to injure it. And hence it is natural to conclude, that phlogiſton is the principal pabulum or food of plants, upon which their nouriſhment and increaſe very materially depend.

Dr. Prieſtley's experiments on this ſubject were made in 1771 and 1772; and his account of them

was preſented to the Royal Society in 1773. He has ſince diſcovered, that *light* is neceſſary to enable plants to purify air; that pure air, however, is not produced by light or plants, but only by the purification of the impure air to which plants have acceſs [a].

This ſubject has been ſince purſued by Dr. Ingenhouſz, who, in 1779, publiſhed Experiments upon Vegetables, diſcovering their great power of purifying common air in the ſunſhine, and of injuring it in the ſhade, and at night, &c.—From theſe experiments he has obſerved, that plants correct bad air, in a complete manner, in a few hours; that this wonderful operation is not owing merely to the vegetation of the plant, but to the influence of the light of the ſun upon it: that plants, expoſed to the light of the ſun, have likewiſe the ſurpriſing faculty of elaborating the air which they contain, and have abſorbed from the common atmoſphere, into real dephlogiſticated air; which they emit, principally from the under ſurface of their numerous leaves, into the common maſs: that this operation does not commence till after the ſun has appeared for ſome time above the horizon, and is carried on more or leſs briſkly, in proportion to the clearneſs or dulneſs of the day; that this production of pure air diminiſhes toward the cloſe of the day, and ceaſes entirely at ſunſet, except in a few plants which perform this function ſomewhat longer than others: that acrid, ill-ſcented, and even the moſt poiſonous plants, perform this office in common with the mildeſt and moſt ſalutary.

Dr. Ingenhouſz has further obſerved, that all plants whatever emit a noxious air *in the night*; and even thoſe which excel others in yielding the pureſt air in the ſunſhine, ſurpaſs them in the power of infecting the circumambient air in the dark, and to ſuch a de-

[a] Obſervations on Air, vol. i. p. 49, 87. vol. iv. p. 293, 305. vol. v. p. 12, 18, &c.

gree, that, even in a few hours, they render a large quantity of good air ſo noxious, that an animal confined in it loſes its life in a few ſeconds [a]; and that, even in the daytime, plants ſhaded by high buildings, or growing under a dark ſhade of other plants, emit an air that is noxious to animals.

This intelligent philoſopher has likewiſe obſerved, that the *flowers* of plants, univerſally, render the air highly noxious, equally by night and by day [b]: that their roots, detached from the ground, poſſeſs the ſame property, ſome few excepted: that fruits, in general, even the moſt delicious, have this deleterious quality (but principally in the dark) to ſuch an aſtoniſhing degree, as to endanger the life of a perſon who ſhould happen to be ſhut up in a ſmall and cloſe room, where a great quantity of them is ſtored up: and laſtly, that the light of the ſun, ſingly, has not the power of purifying any quantity of air expoſed to it, without the concurrence of the plants.

Dr. Ingenhouſz infers, from his experiments, that the pure or dephlogiſticated air thus obtained from plants expoſed to the light of the ſun, did not antecedently exiſt in the leaves in this pure ſtate, but is only ſecreted out of them, when it has undergone

[a] Dr. Ingenhouſz, however, has obſerved, that the quantity of noxious air which plants emit at night, is ſo inconſiderable in compariſon with that of the dephlogiſticated air which they yield in the day, that, on a rough calculation, he ſuppoſes the poiſonous air, yielded during a whole night, does not amount to the hundreth part of the dephlogiſticated air, which the ſame plant would emit in the ſpace of two hours, in a fair day.

[b] A few flowers of the honeyſuckle expoſed even to the ſun's light in the middle of the day, rendered a body of air, equal to two pints, highly noxious, in three hours. Theſe flowers, ſays the doctor, like all others, after having thus rendered truly fatal a body of air equal to two pints, have loſt nothing of their fragrance. The air itſelf, which they have poiſoned, is impregnated with the ſame fragrant ſmell as the flowers themſelves; ſo that a perſon ſhut up in a ſmall and cloſe room, containing a large quantity of the moſt fragrant flowers, might loſe his life by this moſt treacherous of all poiſons. He has heard of more than one inſtance of ſudden deaths, which were too probably occaſioned by this hitherto unſuſpected cauſe.

a purification, or kind of tranſmutation.—His experiments, likewiſe, ſtrongly confirm the idea, that the action of vegetables upon air, at leaſt in the day, is directly oppoſite to that of animals. The latter inſpire the common atmoſpherical air into their lungs, and then emit it thence, loaded with a foreign, phlogiſtic, and noxious principle. Vegetables, on the contrary, abſorbing common air, retain, by ſome peculiar economy, the phlogiſtic matter it naturally contains, for their nouriſhment, or other purpoſes; and then emit the air, thus rendered pure or dephlogiſticated, as being, to them, noxious or excrementitious.

It has been already ſaid, that neither candles will burn nor animals live, beyond a certain time, in a given quantity of air; yet the cauſe of ſuch ſpeedy extinction and death was unknown, and no method was again found out for rendering that empoiſoned air fit for reſpiration, until the experiments and diſcoveries of the two eminent philoſophers, whom I have mentioned laſt. Some proviſion, there muſt be for this purpoſe, as well as for that of ſupporting flame; for, without ſuch a proviſion, the whole atmoſphere would in time become unfit for animal life, and the race of men, as well as of beaſts, would die of a peſtilential diſtemper. And yet we have reaſon to believe, that the air is not leſs proper for reſpiration in our days, than it was above 2000 years ago, which is as far as we can go back in natural hiſtory.

For this important end, therefore, Dr. Prieſtley has ſuggeſted to the divine as well as to the philoſopher, two grand reſources of Nature—the vegetable creation already mentioned, and the ſea and other great bodies of water.

With reſpect to the laſt, Dr. Prieſtley has obſerved, that both the air corrupted by the breath of animals, and that vitiated by other putrid matter, was ſweetened, in a great meaſure, by the ſceptic part infuſing itſelf into water. He concluded, there-

fore, that the ocean, and the great lakes and rivers, that cover ſo large a proportion of the globe, muſt be highly uſeful by abſorbing what is putrid, for the further purification of the atmoſphere; thus beſtowing what would be noxious to man and other animals, upon the formation of marine and other aquatic plants, or upon other purpoſes yet unknown.

In fine, we are aſſured from theſe great diſcoveries, that no vegetable grows in vain; but that, from the oak of the foreſt to the graſs of the field, every individual plant is ſerviceable to mankind; if not always diſtinguiſhed by ſome private virtue, yet making a part of the whole which cleanſes and purifies our atmoſphere. In this the fragrant roſe and deadly nightſhade alike co-operate. Nor are the herbage and woods that flouriſh in the moſt remote and unpeopled regions unprofitable to us, nor we to them, conſidering how conſtantly the winds convey to them our vitiated air, for our relief, and for their nouriſhment. And if ever theſe ſalutary gales riſe to ſtorms and hurricanes, let us ſtill trace and revere the ways of a beneficent Being, who, not fortuitouſly, but with deſign; not in wrath, but in mercy; thus ſhakes the waters and the air together, to bury in the deep thoſe putrid and peſtilential effluvia, which the vegetables upon the face of the earth had been inſufficient to conſume.

Let no preſuming impious railer tax
Creative Wiſdom, as if aught was form'd
In vain, or not for admirable ends.—
Lives there the man, whoſe univerſal eye
Has ſwept at once th' unbounded ſcheme of things;
Mark'd their dependence ſo, and firm accord,
As with unfalt'ring accent to conclude
That *this* availeth nought?—
Till ſuch exiſt, let zealous praiſe aſcend,
And hymns of holy wonder, to that Power,
Whoſe wiſdom ſhines as lovely on our minds,
As on our ſmiling eyes his ſervant-ſun. THOMSON.

XVI. ON THE NATURE AND PROPERTIES OF WATER.

Nymphs! your bright ſquadrons watch with chymic eyes
The cold-elaſtic vapours, as they riſe;
With playful force arreſt them as they paſs,
And to *pure* air betroth the *flaming* gas.
Round their tranſlucent forms at once they fling
Their rapturous arms, with ſilver boſoms cling;
In fleecy clouds their fluttering wings extend,
Or from the ſkies in lucid ſhowers deſcend;
Whence rills and rivers owe their ſecret birth,
And ocean's hundred arms infold the earth.

BOTANIC GARDEN.

IT was the opinion of Thales, and other ancient philoſophers, that Water was the original of all things. Hence Pindar, when he would illuſtrate the ſuperiority of the Olympic games over all others, ſets out with obſerving, that they hold the ſame rank as water does among the elements, and gold among the gifts of Fortune.

Chief of Nature's works divine
Water claims the higheſt praiſe,
Richeſt offſpring of the mine,
Gold like fire, whoſe flaſhing rays,
From afar conſpicuous gleam
Through the night's involving cloud,
Firſt in luſtre and eſteem,
Decks the treaſures of the proud:
So among the liſts of fame
Piſa's honour'd games excel;
Then to Piſa's glorious name
Tune, O Muſe, thy ſounding ſhell.

WEST'S PINDAR.

Nor was this opinion confined to remote antiquity. Van Helmont, and others among the moderns, have likewiſe maintained, that water is the elemental mat-

ter, or ſtamen, of all things, and is alone ſufficient for the production of all the viſible creation. And ſir Iſaac Newton thus expreſſes himſelf on this ſubject: "All birds, beaſts, and fiſhes, inſects, trees, and vegetables, with their ſeveral parts, do grow out of water, and watery tinctures and ſalts; and, by putrefaction, they all return again to watery ſubſtances".

The ſame great philoſopher defines water to be a fluid ſalt, volatile, and void of taſte. But Boerhaave ſets aſide this definition; "for water (he obſerves) is a menſtruum, or diſſolvent of ſalts and ſaline bodies, which does not agree with the notion of its being a ſalt itſelf; for we do not know of any one ſalt that diſſolves another".—By ſome late experiments of Lavoiſier, Watt, Cavendiſh, Prieſtley, and Kirwan, it appears, that water conſiſts of dephlogiſticated air, and inflammable air or phlogiſton intimately united; or, as Mr. Watt conceives, of dephlogiſticated air and phlogiſton, deprived of part of their latent heat. This doctrine is alluded to in my motto[a].

[a] Until very lately water was eſteemed a ſimple element, nor are all the moſt celebratad chymiſts of Europe yet converts to the new opinion of its decompoſition. M. Lavoiſier and others of the French ſchool have moſt ingeniouſly endeavoured to ſhow that water conſiſts of pure air, called by them oxygene, and of inflammable air, called hydrogene, with as much of the matter of heat, or calorique, as is neceſſary to preſerve them in the form of gas. Gas is diſtinguiſhed from ſteam by its preſerving its elaſticity under the preſſure of the atmoſphere, and in the greateſt degrees of cold yet known. The hiſtory of the progreſs of this great diſcovery is detailed in the Memoirs of the Royal Academy for 1781, and the experimental proofs of it are delivered in Lavoiſier's Elements of Chymiſtry. The reſults of which are that water conſiſts of eighty-five parts by weight of oxygene, and fifteen parts by weight of hydrogene, with a ſufficient quantity of calorique. Not only numerous chymical phenomenons, but many atmoſpherical and vegetable facts, receive clear and beautiful elucidation from this important analyſis. In the atmoſphere inflammable air is probably perpetually uniting with vital air and producing moiſture which deſcends in dews and ſhowers, while the growth of vegetables by the aſſiſtance of light is perpetually again decompoſing the water they imbibe from

In contemplating Nature, we ſhall often find the ſame ſubſtances poſſeſſed of contrary qualities, and producing oppoſite effects. Air which liquifies one ſubſtance, dries up another. That fire which is ſeen to burn up the deſert, is often found, in other places, to aſſiſt the luxuriance of vegetation; and water which, next to fire, is the moſt fluid ſubſtance upon earth, gives to all other bodies their firmneſs and durability: ſo that every element ſeems to be a powerful ſervant, capable of either good or ill, and only awaiting external direction, to become the friend or enemy of mankind. Theſe oppoſite qualities, in water in particular, have not failed to excite the admiration and inquiry of the curious.

That water is the moſt penetrating body next to fire, and the moſt difficult to confine, has been proved by various experiments. A veſſel through which water cannot paſs, may retain any thing. Nor is it any objection, that ſyrups and oils will ſometimes paſs through bodies which hold water; this not being owing to the greater ſubtilty and penetrability of their particles, but to the reſin with which the wood of ſuch veſſels abounds, and to which oils and ſyrups are as menſtruums; ſo that, diſſolving the reſin, they make their way through the ſpaces left thereby. But water, on the contrary, not acting on reſins, is retained in the ſame veſſels. And yet it gradually makes its way, even through all woods, and is retainable only in glaſs and metals. It was found, moreover, by an experiment at Florence, that when ſhut up in a ſpherical veſſel of gold, and then preſſed with great force, it made its way through the pores even of the gold: ſo that the moſt ſolid body is permeable to water, under certain circumſtances. It is even found more fluid than air:

the earth, and while they retain the inflammable air for the formation of oils, wax, honey, reſin, &c. they give up the vital air to repleniſh the atmoſphere. *Darwin's Botanic Garden*, part i, page 132.

a body being reputed more fluid than another, when its parts will find way through ſmaller pores. Now air, it is well known, will not paſs through leather; as is evident in the caſe of an exhauſted receiver covered therewith; but water will paſs through leather with eaſe. Air, likewiſe, may be retained in a bladder, which water oozes through. It is found, indeed, that water will paſs through pores ten times ſmaller than air will.—But here it muſt be obſerved, that M. Homberg accounts for this paſſage of water through the narrow pores of animal ſubſtances, which will not admit the air, on the principle of its moiſtening and diſſolving the glutinous matter of the fine fibres of the membranes, and rendering them more pliable and diſtractile; which is what the air, for want of a wetting quality, cannot do. As a proof of this doctrine, he filled a bladder, compreſſed it with a ſtone, and found no air to come out; but placing the bladder, thus compreſſed, in water, the air eaſily eſcaped.

Hence water, from its penetrative power, may be ſuppoſed to enter into the compoſition of all bodies, vegetable, animal, and foſſil; with this particular circumſtance, that it can always be ſeparated, by a gentle heat, from thoſe ſubſtances with which it has been united. Fire, indeed, will penetrate more than water; but it is not ſo eaſily to be ſeparated again.

This property of water, joined with its ſmoothneſs and lubricity, fits it to ſerve as a vehicle for the commodious and eaſy conveyance of the nutritious matter of all bodies. Being ſo fluid, and paſſing and repaſſing ſo readily, it never ſtops up the pores, and leaves room for the following water to bring on a new ſupply of nutritious matter.

The ſame water, however, ſo little coheſive as it is, and ſo eaſily to be ſeparated from moſt bodies, will cohere firmly with ſome others, and bind them together in the moſt ſolid maſſes; though it appears

wonderful, that water, which may be ſhown an almoſt univerſal diſſolvent, ſhould, nevertheleſs, be a great coagulator.

Water, mixed up with earth and aſhes, gives them the utmoſt firmneſs and fixity. The aſhes, for inſtance, of an animal, incorporated with pure water into a paſte, and baked with a vehement fire, become a coppel; which is a body remarkable for this, that it will bear the utmoſt effort of a refiner's furnace. It is, in reality, upon the glutinous nature of water only, that our houſes ſtand: for take the water out of wood, and it becomes aſhes; or out of tiles, and they become duſt.

A little clay, dried in the ſun, becomes a powder, which, mixed with water, ſticks together again, and may be faſhioned to any form; and this, dried again by a gentle fire, or in the ſun, and then baked in a potter's oven by an intenſe fire, becomes little other than a ſtone. The Chineſe earth, of which our porcelain veſſels are made, which hold all liquors, and even melted lead itſelf, is diluted and wrought up with water. In fine, all the ſtability and firmneſs viſible in the univerſe have been aſcribed, by ſome writers, to water alone. Thus, they ſay, ſtone would be an incoherent ſand, did not water bind it together; and thus, again, of a fat, gravelly earth, wrought up with water, and baked, or burnt, we make bricks, tiles, and earthen veſſels, of ſuch exceeding hardneſs and cloſeneſs, that water itſelf cannot paſs through them. And theſe bodies, although to appearance perfectly dry, and deſtitute of water, yet, being pulverized, and put into a retort, and diſtilled, yield an incredible quantity of water. The ſame, it is ſaid, holds of metals; for the parings or filings of lead, tin, antimony, &c. yield water plentifully, by diſtillation; and the hardeſt ſtones, ſea-ſalt, nitre, vitriol, ſulphur, &c. are found to conſiſt chiefly of water, into which they reſolve by the force

of fire. The lapis calcarous, or limeſtone, being expoſed to the fire, affords a prodigious quantity of pure water; and the more of this water is extracted, the more friable does it become, till, at length, it commences a dry calx, or lime, wherein, in lieu of the water ſo expelled, the fire enters, in the courſe of calcination; and this is expelled again, in its turn, by pouring on cold water. Yet the ſame water and calx, tempered together, produce a maſs, ſcarce inferior, in point of ſolidity, to the primitive limeſtone.—Many, if not moſt of the effects, here aſcribed to water, in uniting and conſolidating the parts of various bodies, have been attributed, by modern chymiſts and philoſophers, to the gas, or fixable air, which enters into their compoſition; which eſcapes when they are diſſolved, and which is capable, in certain circumſtances, of being again reſtored to them.

Although water be defined a *fluid*, it has been a controverted point among philoſophers, whether fluidity be its natural ſtate, or the effect of violence. We ſometimes find it appear in a fluid, and ſometimes in a ſolid form; and as the former, in our warmer climate, is the more common, we conclude it to be the proper one, and aſcribe the other to the extraneous action of cold. Boerhaave, however, aſſerts the contrary, and maintains water to be naturally of the cryſtalline kind; ſince, wherever a certain degree of fire is wanting to keep it in fuſion, it readily grows into a hard ſubſtance, under the denomination of ice. Boyle is much of the ſame opinion. Ice, he obſerves, is commonly reputed to be water brought into a preternatural ſtate by cold; but with regard to the nature of things, and, ſetting aſide our arbitrary ideas, it might be as juſtly ſaid, that water is ice preternaturally thawed by heat. If it be urged, that ice left to itſelf, will, upon the removal of the freezing agents, return to water, it

may be anſwered, that, not to mention the ſnow and ice which lie, during the whole ſummer, on the Alps, and other high mountains, even in the torrid zone, we have been aſſured, that, in ſome parts of Siberia, the ſurface of the ground continues more months in the year frozen by the natural temperature of the climate, than thawed by the heat of the ſun; and, a little below the ſurface of the ground, the water that may happen to be lodged in the cavities there, continues in a ſtate of ice all the year round: ſo that, in the heat of ſummer, when the fields are covered with corn, if you dig a foot or two deep, you will find ice, and a frozen ſoil.

Water, if it could be had clear and pure, Boerhaave obſerves, would have all the requiſites of an element, and be as ſimple as fire; but no expedient has hitherto been diſcovered, for procuring it ſo pure. Rain-water, which ſeems the pureſt of all thoſe we know of, is replete with numberleſs exhalations of all kinds, which it imbibes from the air: ſo that, if filtered and diſtilled a thouſand times, feces ſtill remain. The rain-water, moreover, gathered from the roofs of houſes, is a lixivium of the ſalt of tiles, ſlate, and the like, impregnated with the dungs and feces of the animals, birds, &c. depoſited thereon, and the exhalations of numerous other things. It may be added, that all the rain-water, gathered in cities, muſt at leaſt be ſaturated with the ſmoke of a thouſand chimnies, and the various effluvia of a number of perſons, &c. Beſide this, fire is contained in all water; as appears from its fluidity, which is owing to fire alone.

As what is in the air neceſſarily mixes itſelf with water, it hence appears impoſſible to have ſuch a thing as pure water. If you percolate it through ſand, or ſqueeze it through pumice; or paſs it through any other body of the ſame kind, you will always have ſalt remaining. Even diſtillation can-

not render it pure; for it leaves air therein, which neceſſarily abounds in corpuſcles of all ſorts.

The water that flows within, or upon the ſurface of the earth, contains various earthly, ſaline, metallic, vegetable, or animal particles, according to the ſubſtances over or through which they paſs.

The pureſt of all waters we can any way obtain, is that diſtilled from ſnow, gathered in a clear, ſtill, pinching night, in ſome very high place; taking none but the outer or ſuperficial part of it. By a number of repeated diſtillations, the greateſt part of the earth, and other feces, may be ſeparated from this: and this is what we muſt be contented to call pure water. In a word, it is the opinion of Boerhaave, that no perſon ever ſaw a drop of pure water; that the utmoſt of its purity known, amounts only to its being free from this or that ſort of matter; that it can never, for inſtance, be quite deprived of ſalt; ſince air will always accompany it, and air always contains ſalts.

Many of the moſt eminent chymiſts have made experiments, in order to aſcertain the converſion of water into earth. Boyle relates, that an ounce of water, diſtilled carefully in glaſs veſſels two hundred times, yielded ſix drams of a white, light, inſipid earth, fixed in the air, and indiſſoluble in water. Hence he concludes, that the whole water, by further proſecuting the operation, might be converted into earth. Godfrey, and others, concur in this opinion; but Boerhaave (who attributes the earth obtained by Boyle to the duſt floating in the air, and to the inſtruments employed in the operation) is ſupported by Macquer, and others, in maintaining, that pure water is unalterable, and incapable of being decompoſed; ſo that whatever be the ſubſtances with which it is combined, when ſeparated from theſe and ſufficiently purified (and alſo when diſtilled ſingly, or mixed with other ſubſtances) its nature and eſſential properties ſtill remain unchanged.

Water ſeems to be diffuſed every where and to be preſent in all ſpace, where there is matter. There are few bodies in nature that will not yield water; and it is even aſſerted, that fire itſelf is not without it. Among other remarkable circumſtances, it has been obſerved, that bones dead and dried twenty-five years, and thus become almoſt as hard as iron, have yet, by diſtillation, afforded half their weight of water.

Water is a very volatile body: it is entirely reduced into vapour, and diſſipated, when expoſed to the fire and unconfined. Heated in an open veſſel, it has been obſerved to acquire no more than a certain determinate degree of heat, how intenſe ſoever the fire to which it is expoſed; and this greateſt degree of heat is that which it has at the moment before it begins to boil.

It was formerly imagined, that water was incompreſſible, and, therefore, non-elaſtic; an opinion, founded on the famous Florentine experiment already mentioned, as proving its penetrative power. But the validity of the inferences drawn from this experiment have been juſtly queſtioned; Mr. Canton having proved, by very accurate experiments, that water is actually compreſſed by the weight of the atmoſphere.

But not to be too diffuſive on this ſubject, I ſhall endeavour to ſtate concisely the nature of the component particles of water, and then its various uſes.

Firſt: the particles of water are, as to our ſenſes, infinitely ſmall, whence their penetrative power. 2. Very ſmooth and ſlippery, or void of any ſenſible aſperities. 3. Extremely ſolid. 4. Perfectly tranſparent, and as ſuch inviſible [a]. 5. If water be

[a] Pure water, incloſed in a veſſel hermetically ſealed, projects no ſhadow; ſo that the eye ſhall not be able to diſcover, whether the veſſel have water in it or not; beſides, the cryſtals of ſalts, when the water is ſeparated from them, loſe their tranſparency.

conſidered as conſiſting of ſpherical, or cubical particles, hollow within-ſide, and of a firm texture, here will be enough to account for the difficulty of compreſſing it, and alſo for its being light, fluid, and volatile; its firmneſs and ſimilarity will make it reſiſt ſufficiently; and its vacuity renders it light enough, &c. And the little contact between ſpherules (if, indeed, they touch at all) will account for the weakneſs of its coheſion. 6. Water is the moſt inſipid of all bodies; the taſte we ſometimes obſerve therein, not ariſing from the mere water, but from ſalt, vitriol, or other bodies mixed with it. And, laſtly, it is perfectly inodorous, and void of the leaſt ſmell.

The uſes of water are infinite; in food, medicine, agriculture, navigation, and divers of the arts. As a food it is one of the moſt univerſal drinks in the world; and, if we may credit many of our lateſt and moſt judicious phyſicians, it is alſo one of the beſt. As a medicine, it is found internally a powerful febrifuge; and excellent againſt colds, coughs, the ſtone, ſcurvy, &c. Externally, its effects are not leſs conſiderable. In agriculture and gardening, water is allowed abſolutely neceſſary to vegetation. Many naturaliſts have even maintained it to be the vegetable matter, or the only proper food of plants; but Dr. Woodward has overturned that opinion, and endeavoured to ſhow, that the office of water in vegetation is only to be a vehicle to a terreſtrial matter, of which vegetables are formed; and that it does not itſelf make any addition to them[a]. Water is of the utmoſt uſe in chymiſtry: being one of the great inſtruments by which all its operations are performed, and it is of the greateſt ſervice in divers of the mechanical arts, and ordinary occaſions of life.

[a] See No. XXIV, On the Food of Plants.

XVII. ON FOUNTAINS AND RIVERS.

Addidit et fontes, immenſaque ſtagna lacuſque;
Fluminaque obliquis cinxit decliva ripis:
Quæ diverſa locis partim ſorbentur ab ipsâ;
In mare perveniunt partim, campoque recepta
Liberioris aquæ, pro ripis littora pulſant. OVID.

Fountains and ponds he adds, and lakes immenſe;
Deſcending ſtreams the winding borders fence.
This, deep-abſorb'd, the darkſome cavern laves:
Theſe to the ocean roll their azure waves;
There, uncontroll'd, they meet the roaring tide,
And daſh, for verdant banks, the hoar cliff's ſide.

WHAT a delightful ornament to a country is the winding courſe of a river! How much more exquiſitely enchanting does it render the moſt beautiful landſcape! And of what an unſpeakable variety of benefits is it productive, to the countries through which it flows! Hence rivers, in all their diverſities of ſcenery, ever appear a favourite theme in poetical compoſition. Homer ſeldom mentions the country of any of his great perſonages, without introducing the principal river that waters it, by ſome diſtinguiſhing characteriſtic. The Eridanus of the ancients (the modern Po) has been celebrated by Virgil, Claudian, and Lucan; Denham and Pope have immortalized the Thames; and even the rivers in ſavage climes, that roll their immenſity of waters through vaſt ſolitary wilds, have neither been neglected nor unſung by our deſcriptive poets.

When we contemplate a river at its fountain head, and perceive that, at firſt, it is nothing more than a little vein of water, oozing from ſome hill upon a bed of clay or ſand, we naturally inquire into the cauſes of this phenomenon, or, in other

words, into the origin of fountains and rivers. Concerning this ſubject natural philoſophers have formed very different conjectures. Thoſe who imagine that fountains owe their origin to waters brought from the ſea by ſubterranean ducts, give a tolerable account how they loſe their ſaltneſs by percolation, as they paſs through the earth; but they find great difficulty in explaining by what power the water riſes above the level of the ſea to the tops of mountains, where ſprings generally abound; it being contrary to the laws of hydroſtatics, that a fluid ſhould riſe in a tube above the level of its ſurface. And ſir Richard Blackmore, in the firſt book of his poem entitled Creation, while he ſeems to admit this theory, thus inquires:

Tell by what paths, what ſubterranean ways,
Back to the fountain's head the ſea conveys
The refluent rivers, and the land repays?
Tell what ſuperior, what controlling cauſe
Makes waters, in contempt of Nature's laws,
Climb up, and gain th' aſpiring mountain height,
Swift and forgetful of their native weight?
What happy works, what engines under ground,
What inſtruments of curious art are found,
Which muſt with everlaſting labour play,
Back to their ſprings the rivers to convey,
And keep their correſpondence with the ſea?

Des Cartes, in order to ſolve this difficulty, imagined, that after the water is become freſh by percolation, it is raiſed out of the caverns of the earth in vapours toward its ſurface; where meeting with rocks near the tops of mountains, in the form of arches or vaults, it adheres to them, and runs down their ſides (like water in an alembic) till it meets with proper receptacles, from which it ſupplies the fountains. Varenius and others imagine, that water may riſe through the pores of the earth, as through capillary tubes, by attraction. They illuſ-

trate the riſe of ſea-water up into mountains and hills, by putting a little heap of ſand or aſhes, a loaf of bread, or the like, into a baſin of water; in which caſe the ſand, &c. will repreſent the dry land, or an iſland, and the baſin of water the ſea around it. Here the water in the baſin will riſe to or near the top of the heap, in the ſame manner, and from the ſame principle, as the waters of the ſea, lakes, &c. riſe in the hills. The principle of aſcent in both is accordingly ſuppoſed to be the ſame with that of the aſcent of liquids in capillary tubes, or between contiguous planes, or in a tube filled with aſhes; all which are generally accounted for from the doctrine of attraction. But to each of theſe theories there are inſurmountable objections: and Thomſon, whoſe philoſophical deſcriptions are generally unexceptionable, has particularly endeavoured to refute the latter.

Some ſages ſay, that where the numerous wave
For ever laſhes the ſurrounding ſhores,
Drill'd through the ſandy ſtratum, every way,
The waters with the ſandy ſtratum riſe;
Amid whoſe angles infinitely ſtrain'd,
They joyful leave their jaggy ſalts behind,
And clear and ſweeten, as they ſoak along.
Nor ſtops the reſtleſs fluid mounting ſtill,
Tho' oft amid th' irriguous vale it ſprings;
But to the mountain courted by the ſand,
That leads it darkling on in faithful maze,
Far from the parent-main, it boils again
Freſh into day; and all the glittering hill
Is bright with ſpouting rills. But hence this vain
Amuſive dream! Why ſhould the waters love
To take ſo far a journey to the hills,
When the ſweet vallies offer to their toil
Inviting quiet, and a nearer bed?
Or if, by blind ambition led aſtray,
They muſt aſpire; why ſhould they ſudden ſtop
Among the broken mountain's ruſhy dells,

And, ere they gain its higheſt peak, deſert
Th' attractive ſand that charm'd their courſe ſo long?
Beſides, the hard agglomerating ſalts,
The ſpoil of ages would impervious choak
Their ſecret channels; or, by ſlow degrees,
High as the hills protrude the ſwelling vales:
Old ocean too, ſuck'd thro' the porous globe,
Had long, ere now, forſook his horrid bed,
And brought Deucalion's watery times again.

Another opinion, which has been very generally received, is that of Mariotte, in his Traité du Mouvemen des Eaux, who attributes the riſe of ſprings to the rains and melted ſnow. According to him, the rain-water which falls upon the hills and mountains, penetrating the ſurface, meets with clay or rocks contiguous to each other. It runs along theſe, without being able to penetrate them, till, being got to the bottom of the mountain, or to a conſiderable diſtance from the top, it breaks out of the ground, and thus forms the ſprings.—But, in order to examine this opinion, M. Perrault and de la Hire endeavoured, by an experiment, to eſtimate the quantity of rain and ſnow that fell in a year; and the reſult of their inquiries was, that the quantity which fell was not ſufficient to ſupply the rivers; for that thoſe of England, Ireland, and Spain diſcharge a greater quantity of water annually, than the rain, according to their experiment, was able to ſupply. They likewiſe found, that the quantity of water raiſed in vapour, one year with another, was thirteen times more than falls in rain; which was a plain indication, that the water of fountains cannot be entirely ſupplied by rain or melted ſnow.

Dr. Halley's ſyſtem is that which ſeems to have given the moſt general ſatisfaction. He attributes the origin of ſprings to vapours raiſed by the action of the ſun, as well as by the agitation of the winds, from ſeas, lakes, &c. He made ſeveral experiments

in order to ſhow, that vapour is a ſufficient fund to ſupply all our ſprings, rivers, &c. For inſtance, in order to find the quantity of water which the Mediterranean receives, he allowed the moſt conſiderable rivers that run into it, namely, the Iberus, Rhone, Tyber, Po, Danube, Neiſter, Boriſthenes, Tanais, and Nile, each to furniſh ten times as much water as the Thames; not that any of them are in reality ſo great, but thus to allow for the ſmall rivulets. Now the Thames is found, by calculation, to evacuate 203,000,000 tuns of water daily. All the other nine rivers, therefore, will only evacuate 1827 millions of tuns in a day; which is little more than a third of what he had demonſtrated, by his preceding experiments, to be raiſed in that time in vapour. And hence, this great man has diſcovered a ſource, abundantly ſufficient for the ſupply of fountains.

Dr. Halley next proceeds to account for his theory on the principles of evaporation. He conſiders, that if an atom of water was expanded into a bubble, ſo as to be ten times as big in diameter as when it was water, that atom would become ſpecifically lighter than the air; and therefore would riſe, ſo long as the warmth, which firſt ſeparated it from the ſurface of the water, ſhould continue to diſtend it to the ſame degree; and conſequently that vapours may be raiſed from the ſea in that manner, till they arrive at a certain height in the atmoſphere, in which they find air of equal ſpecific gravity with themſelves. Here they will float, till being condenſed by cold, they become ſpecifically heavier than the air, and fall down in dew; or being driven by the winds againſt the ſides of mountains (many of which far exceed the uſual height to which vapours would of themſelves aſcend) are compelled by the ſtream of air to mount up with it to their ſummits. There, being condenſed into water, they preſently

precipitate, and oozing down by the crannies of the ſtones, part of them enters into the caverns of the hills. Theſe being once filled, all the overplus of water that comes thither, runs over by the loweſt place, and breaking out by the ſides of the hills, forms ſingle ſprings. Many of theſe running down by the vallies, between the ridges of the hills, and coming to unite, form little rivulets or brooks. Many of theſe meeting in one common valley, and by gaining the plain ground, having grown leſs rapid, become a river: and many of theſe uniting, form ſuch prodigious ſtreams of water as the Volga, the Danube, and the Rhone.

Thus, one part of the vapours that are blown on the land, is returned by the rivers to the ſea whence it came. Another part falls into the ſea before it can reach the land; which is the reaſon why the rivers do not return ſo much water into the Mediterranean as is raiſed by vapour. A third part falls upon the low grounds, and furniſhes the pabulum or nutriment of plants. But the circulation does not end even here; for it is again exhaled into vapour by the action of the ſun, and returned to the great world of waters whence it firſt aroſe.

Thomſon, in his poetical account of the origin of fountains, ſeems to have blended the theories of Mariotte and Halley:

Where lurk the dark eternal ſprings,
That, like creating Nature, lie concealed
From mortal eye, yet with their laviſh ſtores
Refreſh the globe, and all its joyous tribes?
O thou pervading Genius, given to man,
To trace the ſecrets of the dark abyſs,
O, lay the mountains bare! and wide diſplay
Their hidden ſtructure to th' aſtoniſh'd view!
* * * * *
Amazing ſcene! Behold! the glooms diſcloſe;
I ſee the rivers in their infant-beds!

Deep, deep I hear them, lab'ring to get free!
I ſee the leaning ſtrata, artful rang'd;
The gaping fiſſures to receive the rains,
The melting ſnows, and ever-dripping fogs.
Strow'd bibulous above I ſee the ſands,
The pebbly gravel next, the layers then
Of mingled moulds, of more retentive earths,
The guttur'd rocks, and mazy-running clefts;
That, while the ſtealing moiſture they tranſmit,
Retard its motion, and forbid its waſte.
Beneath th' inceſſant weeping of theſe drains
I ſee the rocky ſyphons ſtretch'd immenſe,
The mighty reſervoirs of harden'd chalk,
Or ſtiff-compacted clay, capacious form'd.
O'erflowing thence, the congregated ſtores,
The cryſtal treaſures of the liquid world,
Thro' the ſtirr'd ſands a bubbling paſſage burſt;
And welling out, around the middle ſteep,
Or from the bottoms of the boſom'd hills,
In pure effuſion flow. United, thus,
Th' exhaling ſun, the vapour-burden'd air,
The gelid mountains, that to rain condens'd
Theſe vapours in continual current draw,
And ſend them, o'er the fair-divided earth,
In bounteous rivers to the deep again,
A ſocial commerce hold, and firm ſupport
The full-adjuſted harmony of things.

But although the theory of Dr. Halley appears thus beautiful, and ſeems indeed to be moſt generally adopted, it muſt ſtill be confeſſed to be incumbered with great difficulties. The perpetuity of many ſprings, which always yield the ſame quantity when the leaſt rain or vapour is afforded, as well as when the greateſt, is a ſtrong objection to both. Dr. Derham mentions a ſpring at Upminſter, in Eſſex, which he could never perceive by his eye to be diminiſhed, in the greateſt droughts, even when all the ponds in the country, as well as an adjoining brook, had been dry for ſeveral months together; nor ever to be increaſed in the moſt rainy ſeaſons,

excepting perhaps for a few hours, or at moſt for a day, from ſudden and violent rains. He, therefore, juſtly concludes, that had this ſpring its origin from rain or vapour, there would be found an increaſe or decreaſe of its water, correſponding to the cauſes of its production. Another important thing muſt not be forgotten of this Upminſter ſpring, and of thouſands of others; namely, that it breaks out of ſo inconſiderable an eminence, as can have no more influence on the condenſation of the vapours, or ſtopping the clouds, than the lower lands about it.—Ricciolus, and other naturaliſts, deny that rain or dew can be a ſufficient ſupply for the great perennial ſprings, and much leſs for the conſtant current of the larger rivers. The Volga alone, they ſay, pours forth as much water in a year's time into the Caſpian ſea, as would ſuffice to drown the ſurface of the whole earth. They affirm, moreover, that this river, and the other rivers on the ſeveral parts of the globe, upon a very moderate calculation, diſcharge at leaſt as much water into the ſea, as falls upon the ſurface of the whole earth, in rains, miſts, dews, ſnows, &c. in a like ſpace of time.—Nor, upon Dr. Halley's theory, can they account for the origin of hot and ſalt ſprings, nor of thoſe ſprings which riſe in places where there falls little or no rain.—Hence they have recourſe, and particularly Dr. Plot, in his Origine Fontium, to certain ſubterranean communications between the ſea, and the ſources of fountains, rivers, and the larger ſprings, by which theſe are ſupplied; and they aſſert that there are certain charybdes, or apertures, which ſwallow the ſea for this purpoſe.

Whither then ſhall we wander in ſearch of certainty, when the moſt learned diſagree; when long and laborious calculations are adduced by all ſides, that ſeem only to involve the ſubject in obſcurity? But, whatever be the uncertainty of philoſophers on

this ſubject, the unſpeakable advantages which we derive from fountains and rivers are obvious to the moſt uninformed. Omniſcience alone can comprehend all the operations of Omnipotence. Nor is it only in the great work of our Redemption, but in the aſtoniſhing myſteries of Nature, that we may exclaim with the apoſtle Paul: "O the depth of the riches both of the wiſdom and knowledge of God! How unſearchable are his judgements, and his ways paſt finding out!---Of him, and through him, and to him, are all things: to whom be glory for ever, Amen".

I might enlarge this diſcuſſion with a variety of intereſting particulars relative to fountains and rivers. But I ſhall wave theſe, for the preſent, in order to lay before my readers a poetical deſcription, never publiſhed before, of the progreſs of a river from its ſource to the ſea. As it is intended to be deſcriptive only of ſcenes that may be ſuppoſed to be familiar to an Engliſh eye, it takes no notice of the thundering cataracts, golden ſands, and other objects of ſavage climes; nor will it be conſidered, perhaps, as defective, in not containing a ſingle alluſion to river-gods and water-nymphs, or to any of the trite machinery of ancient fiction.

Behold the riv'let, from its parent-ſource,
Steal thro' the thicket with unheeded courſe;
Of future greatneſs yet unconſcious ſtray,
Like infant princes, in their infant play;
O'er its rough bed in lulling murmurs flow,
Or thro' the breezy ſedge meand'ring flow.
And now in waves, impelling-ſoft, it roves
Thro' ſunny banks, or deep-involving groves;
From ſiſter-ſtreams receives enriching aid,
And wonders at the progreſs it has made.
Now tufty iſles the doubtful ſtream divide,
The ſacred haunts of Cygnus' plumy pride:
O'er the clear cryſtal hangs the woody ſcene,
The weeping willow, or bright evergreen.

The trembling branches, all inverted, ſeem
To point to other ſkies below the ſtream.
The ſun reflected, gilds th' illuſive deep,
Or ſhadowing winds the mantling ſurface ſweep.
Here thick'ning graſs invites the mower's ſithe,
The buſy groups of men and maidens blithe:
Here the ſhorn meadow brightens to the eye;
The ſcatter'd herds lie ruminating nigh:
Each riſing charm the bounteous ſtream beſtows,
The graſs that thickens, and the flow'r that blows.
And while the vale the humid wealth imbibes,
The foſt'ring wave ſuſtains the finny tribes;
The carp, with golden ſcales, in wanton play;
The trout, in crimſon-ſpeckled glory gay;
The red-finn'd roach, the ſilver-coated eel,
The pike, whoſe haunt the twiſted roots conceal;
The healing tench, the gudgeon, pearch, and bream,
And all the ſportive natives of the ſtream.
The vig'rous ſtream now drives the buſy mill,
And now diſdains the little name of *rill*.
The cluſt'ring cots adorn its flow'ry ſides,
Where bleſt Content, with roſy Health, abides.
Or here the villa's ſimple charms invite,
Where rural eaſe and elegance unite.
There, gaudy Art her cumb'rous pomp diſplays,
Where gay Caprice bedecks the verdant maze;
The palace, column, temple, ſtatue, rears;
While Nature faſhionably dreſt appears,
And now the bridge, by buſy mortals trod,
High over-arches the ambitious flood.
Now crowded cities, lofty turrets riſe,
And ſmoky columns mingling with the ſkies;
Where the raſh youth their limbs exulting lave;
Where oars innum'rous beat the aſtoniſh'd wave.
On the proud ſurface ſwells th' impatient ſail,
And gladden'd coaſts the welcome ſtreamers hail.
Expanding ſtill the rough'ning waters glide,
In haſte to mingle with the briny tide[a];
Till ſea-like grown, they now diſdain all bound,
And ruſhing to the deep, reſiſtleſs pour around.

[a] Ove nei ſalſi flutti
Il bel Tamigi amareggiando intoppa. ARIOSTO.

And thus the youth whom Education leads
Thro' Wiſdom's paths, and Virtue's peaceful meads,
Tho' in his tender years he thoughtleſs play,
Nor think his flow'ry ſpring will paſs away;
Tho' trifling ſcenes and trifling toys amuſe,
Yet ſtill his courſe, progreſſive, he purſues.
Freſh ſtreams of knowledge all their ſtores impart,
Wealth to his mind, and goodneſs to his heart;
Aſpiring Faith and Piety, which here
Teach whom to love, and whom alone to fear.
Rich fruits of virtue God himſelf ſupplies,
And Pleaſure's flow'rs in rich ſucceſſion riſe;
For Virtue ever kindred Pleaſure meets,
And bright Example ſheds her fragrant ſweets:
Th' inſpiring force of excellence confeſt,
Bleſt in himſelf he renders others bleſt.
Life's ſummer ſhines, declining autumn glows,
Serene he welcomes winter's ſoft repoſe:
Then when he counts accumulated years,
In joyful retroſpect each ſcene appears;
Yet ſtill he preſſes on with heav'nly views,
Still the bright mark, the radiant prize purſues,
Sees heav'nly fields in bright'ning proſpect riſe,
And pants impatient for his native ſkies;
Till freed at laſt, his ſpirit ſoars away
To ſcenes of boundleſs bliſs, and everlaſting day.

XVIII. ON THE ALTERNATE SUCCESSION OF DAY AND NIGHT,

AND THE VARIETY AND VICISSITUDES OF THE SEASONS.

Frigora miteſcunt Zephyris: Ver proterit Æſtas,
Interitura, ſimul
Pomifer Autumnus fruges effuderit; et mox
Bruma recurrit iners. HORACE.

In vernal gales cold Winter melts away;
Soon waſtes the Spring in Summer's burning ray;
Yet Summer dies in Autumn's fruitful reign,
And ſlow-paced Winter ſoon returns again.
FRANCIS.

IN all the works of the omnipotent Creator, we perceive that ſublimity and ſimplicity are the ſtriking characteriſtics. From a few principles he produces the moſt aſtoniſhing effects, and charms us no leſs by the infinite diverſity of his operations, than by the ſkill and contrivance that are manifeſted in them. The ſun and moon, the planets and the ſtars, are all governed by the ſame invariable laws. The ſingle principle of gravitation pervades the whole univerſe, and puts every ſpring and wheel of it in motion. From the indiſcernible atom to the vaſt and immeaſurable luminaries of heaven, every thing is ſubject to its dominating influence; and from this active, inviſible, and invigorating agent, proceed all that order, harmony, beauty, and variety, which are ſo conſpicuous in the works of creation.

Of all the effects reſulting from this admirable ſcene of things, none can be more pleaſing to the Contemplative Philoſopher, than the alternate ſucceſſion of day and night, and the regular return of the ſeaſons.

Sweet is the breath of morn,
And ſweet the coming on of grateful evening, mild.
MILTON.

When the ſun firſt appears in the horizon, all Nature is animated by his preſence: the magnificent theatre of the univerſe opens gradually to our view; and every object around us excites ideas of wonder, pleaſure, and adoration. After "riding in all his brightneſs" through the vault of heaven, this glorious orb is again hidden from our ſight, and we are preſented with a new ſcene of equal grandeur and ſublimity. The heavens are covered with innumerable ſtars: the moon, "riſing in clouded majeſty, unveils her peerleſs light"; while the ſilent ſolemnity of the ſcene inſpires the mind with unutterable ideas.

With what an awful world-revolving power
Were firſt th' unweildy planets launch'd along
Th' illimitable void! Thus to remain
Amid the flux of many thouſand years,
That oft has ſwept the toiling race of men
And all their labour'd monuments away,
Firm, unremitting, matchleſs, in their courſe;
To the kind temper'd change of night and day,
And of the ſeaſons ever ſtealing round,
Minutely faithful. THOMSON.

Variety is the ſource of every pleaſure; and the bountiful Author of Nature, in the magnificent diſplay of his wiſdom and power, has afforded us every poſſible means of entertainment and inſtruction. What a pleaſing ſucceſſion of ſcenes reſults from the gradual viciſſitudes of the ſeaſons! Spring, ſummer, autumn, and winter, lead us inſenſibly through the varied circle of the year, and are no leſs pleaſing to the mind, than neceſſary toward bringing into maturity the various productions of the earth. Whether the ſun flames in the ſolſtice, or pours his mild ef-

fulgence from the equator, we equally rejoice in his preſence, and bleſs that omniſcent Being, who gave him his appointed courſe.

At one wide view God's eye ſurveys
His works in every diſtant clime;
He ſhifts the ſeaſons, months, and days,
The ſhort-liv'd offspring of revolving time;
By turns they die, by turns are born.
Now cheerful Spring the circle leads,
And ſtrews with flowers the ſmiling meads;
Gay Summer next, whom ruſſet robes adorn,
And waving fields of yellow corn;
Then Autumn, who with laviſh ſtores the lap of Nature ſpreads;
Decrepit Winter, laggard in the dance,
(Like feeble age oppreſt with pain)
A heavy ſeaſon does maintain,
With driving ſnows and winds and rain;
Till Spring, recruited to advance,
The various year rolls round again. HUGHES.

The ſucceſſion of night and day, and the variety and viciſſitudes of the ſeaſons, are phenomenons which depend upon the moſt ſimple and evident principles. The ſucceſſion of day and night is occaſioned merely by the rotation of the earth upon its axis. The earth turns regularly round this imaginary line, called its axis, once in every twenty-four hours; and as only one half of the globe can be illuminated at the ſame time, it is evident, that any particular place upon the earth will ſometimes be turned toward the ſun, and ſometimes from it; and being conſtantly ſubject to theſe various poſitions, will enjoy a regular return of light and darkneſs. As long as the place continues in the enlightened hemiſphere it will be day; and when, by the diurnal rotation of the earth, it is carried into the dark hemiſphere, it will be night.

The motion of the earth upon its axis is from

weſt to eaſt; and this occaſions an apparent contrary motion of the celeſtial bodies from eaſt to weſt. The ſun, for inſtance, ſeems to make his daily progreſs through the heavens from the eaſt toward the weſt; but this is an optical fallacy, ariſing from the oppoſite motion of the earth: for, a ſpectator being placed in any part of the dark hemiſphere, will, by the rotation of the earth upon its axis, be brought gradually into the enlightened one; and, as the ſun firſt appears to him in the eaſt, that luminary will, it is evident, ſeem to aſcend higher and higher toward the weſt, in proportion as the ſpectator moves in a contrary direction toward the eaſt; ſo that whether the earth turns round upon its axis once in twenty-four hours, or whether the ſun, with all the other celeſtial bodies, moves round in that time, the appearances will be exactly the ſame: but the latter notion has been long exploded as unphiloſophical and abſurd.

Every planet, on which obſervations have been made, is found to have a revolution upon its axis; and, as this revolution is the cauſe of a conſtant ſucceſſion of day and night to every part of their ſurfaces, ſo an inclination of the axis of any planet to the plane of its orbit, occaſions the viciſſitudes of the ſeaſons. Jupiter, whoſe axis is nearly perpendicular to the plane of his orbit, has equal days and nights, continually, on every part of his ſurface; their length being each four hours and twenty-eight minutes. But Venus, the Earth, and Mars, having each their axis inclined to the plane of their orbits, in an angle conſiderably leſs than that of 90 degrees, are ſubject to an annual change of their ſeaſons, and a great variety in the length of their days and nights. But a more ſcientific diſcuſſion on this ſubject would carry me into too wide a field, and could not be rendered intelligible to my readers, without the aſſiſtance of ſome plates, and a variety

of references to them. I ſhall refer, therefore, for a more copious illuſtration of the ſubject, to the ingenious author to whom I am indebted for ſome of theſe obſervations [a].

Each ſeaſon of the year has its incipient, confirmed, and receding ſtate; and each, like the priſmatic colours, is undiſtinguiſhably blended, in its origin and termination, with that which precedes, and that which follows it.

A ſimple train,
Yet ſo delightful mix'd, with ſuch kind art,
Such beauty and beneficence combin'd;
Shade unperceiv'd ſo ſoftening into ſhade;
And all ſo forming an harmonious whole,
That as they ſtill ſucceed, they raviſh ſtill.

THOMSON.

Our favourite poet of the Seaſons has not been inattentive to theſe circumſtances in the conduct of his delightful poem. His *Spring* begins with a view of the ſeaſon, while yet unconfirmed, and partaking of the roughneſs of Winter; and it is not till after ſeveral ſteps in progreſſion, that it breaks forth in all its ornaments as the favourite of love and pleaſure. His *Autumn*, after a rich proſpect of its bounties and ſplendours, gently fades into "the ſere, the yellow leaf", and with the lengthened night, the clouded ſun, and the riſing ſtorm, ſinks into the arms of Winter. To produce ſomething of a ſimilar effect in his *Summer*, a ſeaſon which, on account of its uniformity of character, admits not of any ſtrongly-marked gradations, he has compriſed the whole of his deſcription within the limits of a ſingle day, purſuing the courſe of the ſun from its riſing to its ſetting. A ſummer's day is, in reality, a juſt model of the entire ſeaſon. Its beginning is moiſt and tem-

[a] Bonnycaſtle's Introduction to Aſtronomy.

perate; its middle, ſultry and parching; its cloſe, ſoft and refreſhing. By thus exhibiting all the viciſſitudes of Summer under one point of view, they are rendered much more ſtriking than they could have been in a ſeries of feebly contraſted and ſcarcely diſtinguiſhable periods.

Spring is characterized as the ſeaſon of the renovation of nature; in which animals and vegetables, excited by the kindly influence of returning warmth, ſhake off the torpid inaction of Winter, and prepare for the continuance and increaſe of their ſeveral ſpecies. The vegetable tribes, as more independent and ſelf-provided, lead the way in this progreſs. The reviviſcent plants emerge, as ſoon as the genial ſhowers have ſoftened the ground, in numbers "beyond the power of botaniſt to reckon up their tribes". The opening bloſſoms and flowers ſoon call forth, from their winter retreats, thoſe induſtrious inſects, which derive ſuſtenance from their nectareous juices. As the beams of the ſun become more potent, the larger vegetables, ſhrubs, and trees, unfold their leaves; and as ſoon as a friendly concealment is thus provided for the various nations of the feathered race, they joyfully begin the courſe of laborious, but pleaſing occupations, which are to engage them during the whole ſeaſon. The delightful ſeries of pictures, ſo truly expreſſive of that genial ſpirit that pervades the Spring, which Thomſon has formed on the variety of circumſtances attending the *paſſion of the groves*, cannot eſcape the notice and admiration of the moſt inattentive eye. Affected by the ſame ſoft influence, and equally indebted to the renewed vegetable tribes for food and ſhelter, he repreſents the ſeveral kinds of quadrupeds as concurring in the celebration of this charming ſeaſon with conjugal and parental rites. Even man himſelf, though, from his ſocial condition, leſs under the dominion of phyſical neceſſities, he

properly deſcribes as partaking of the general ardour.

A ſoft and pleaſing languor, interrupted only by the gradual progreſſion of the vegetable and animal tribes toward their ſtate of maturity, forms the leading character of Summer. The active fermentation of the juices, which the firſt acceſs of genial warmth had excited, now ſubſides; and the increaſing heats rather inſpire faintneſs and inaction than lively exertions. The inſect race alone ſeem animated with peculiar vigour, under the more direct influence of the ſun.

In Autumn the promiſe of the Spring is fulfilled. The ſilent and gradual progreſs of maturation is completed; and human induſtry beholds with triumph the rich productions of its toil. The vegetable tribes diſcloſe their infinitely various form of *fruit*; which term, while, with reſpect to common uſe, it is confined to a few peculiar modes of fructification, in the more comprehenſive language of the naturaliſt, includes every product of vegetation by which the rudiments of a future progeny are developed, and ſeparated from the parent plant. Theſe are in part collected and ſtored up by thoſe animals for whoſe ſuſtenance during the enſuing ſleep of Nature they are provided. The reſt, furniſhed with various contrivances for diſſemination, are ſcattered by the friendly winds which now begin to blow over the ſurface of the earth which they are to clothe and decorate. The groves now loſe their leafy honours; but, before they are entirely tarniſhed, an adventitious beauty, ariſing from that gradual decay which looſens the withering leaf, gilds the Autumnal landſcape with a temporary ſplendour, ſuperior to the verdure of Spring, or the luxuriance of Summer. The infinitely various and ever-changing hues of the leaves at this ſeaſon, melting into every ſoft gradation of tint and ſhades, have long engaged

the imitation of the painter, and the contemplation of the poet and the philoſopher [a].

Theſe unvarying ſymptoms of approaching Winter now warn ſeveral of the winged tribes to prepare for their aërial voyage to thoſe happy climates of perpetual Summer, where no deficiency of food or ſhelter can ever diſtreſs them; and, about the ſame time, other fowls of hardier conſtitution, which are contented with eſcaping the iron Winters of the arctic regions, arrive to ſupply the vacancy. Thus the ſtriking ſcenes afforded by that wonderful part of the economy of Nature, the migration of the birds [a], preſent themſelves at this ſeaſon. The thickening fogs, the heavy rains, the ſwoln rivers, while they deform this ſinking period of the year, add new ſubjects to the pleaſing variety which reigns throughout its whole courſe.

From the fall of the leaf, and withering of the herb, an unvarying death-like torpor oppreſſes almoſt the whole vegetable creation, and a conſiderable part of the animal, during this entire portion of the year. The whole race of inſects, which filled every part of the ſummer landſcape with life and motion, are now either buried in profound ſleep, or actually no longer exiſt, except in the unformed rudiments of a future progeny. Many of the birds and quadrupeds are retired to concealments, from which not even the calls of hunger can force them; and the reſt, intent only on the preſervation of a joyleſs life, have ceaſed to exert thoſe powers of pleaſing, which, at other ſeaſons, ſo much contribute to their mutual happineſs, as well as to the amuſement of their human ſovereign. Their ſocial connections, however, are improved by their wants. In order the better to procure their ſcanty ſubſiſtence, and reſiſt the inclemencies of the ſky, they are taught by inſtinct to

[a] See No. LXI, On the Decay and Fall of the Leaves.

[a] See No. LXV and LXVI, On the Migration of Birds.

aſſemble in flocks; and this proviſion has the ſecondary effect of gratifying the ſpectator with ſomething of novelty and action, even in the drearineſs of a wintry proſpect.

But it is in the extraordinary changes and agitations which the elements undergo during this ſeaſon, that the Contemplative Philoſopher muſt principally look for relief from the gloomy uniformity which reigns through other parts of the creation. Scenes are preſented to the view, which, were they leſs frequent, muſt ſtrike with wonder and admiration the moſt incurious ſpectator. The effects of cold are more ſudden, and, in many inſtances, more extraordinary and unexpected than thoſe of heat. He who has beheld the vegetable productions of even a northern ſummer, will not be greatly amazed at the richer and more luxuriant, but ſtill reſembling growths of the tropics. But one, who has always been accuſtomed to view water in a liquid and colourleſs ſtate, cannot form the leaſt conception of the ſame element as hardened into an extenſive plain of ſolid cryſtal, or covering the ground with a robe of the pureſt white. The higheſt poſſible degree of aſtoniſhment muſt, therefore, attend the firſt view of theſe phenomenons; and, as in our temperate climate but a ſmall portion of the year affords theſe ſpectacles, we find that, even here, they have novelty enough to excite emotions of agreeable ſurpriſe. But it is not to novelty alone that they owe their charms. Their intrinſic beauty is, perhaps, individually ſuperior to that of the gayeſt objects preſented by the other ſeaſons. Where, indeed, is the elegance and brilliancy, that can compare with that which decorates every tree and buſh on the clear morning ſucceeding a night of hoar-froſt? Or what is the luſtre that would not appear dull and tarniſhed, in competition with a field of ſnow juſt glazed over with froſt?

In this picturesque review of the seasons, we may find many noble sources of religious, as well as philosophical sentiment. The Contemplative Philosopher, while he surveys the grand and beautiful objects that every where surround him, will be prompted to lift his eye to the Great Cause of all these wonders, the Planner and Architect of this mighty fabric, every minute part of which so much awakens his curiosity and admiration. The laws by which this Being acts, the ends which he seems to have pursued, must excite his humble researches; and, in proportion as he discovers Infinite Power in the means, directed by Infinite Goodness in the intention, his soul must be wrapt in astonishment, and expanded with gratitude. The economy of Nature will, to such an observer, be the perfect scheme of an All-wise and Beneficent Mind; and every part of the wide creation will appear to proclaim the praise of its great Author.

I must not conclude this paper, without observing, moreover, that the annual space in which the earth performs its revolution round the sun, is so strongly marked by Nature for a perfect period, that all mankind have agreed in forming their computations of time upon it. In all the temperate climates of the globe, the four seasons are so many progressive stages in this circuit, which, like the acts in a well-constructed drama, gradually disclose, ripen, and bring to an end the various business transacted on the great theatre of Nature. The striking analogy which this period, with its several divisions, bears to the course of human existence, has been remarked and pursued by writers in every age and country. Spring has been represented as the youth of the year, the season of pleasing hope, lively energy, and rapid increase [a]. Summer has been resembled to perfect

[a] See No. XXI, Vernal Reflections.

manhood, the ſeaſon of ſteady warmth, confirmed ſtrength, and unremitting vigour. Autumn, while it beſtows the rich products of full maturity, is yet ever haſtening to decline, and has, therefore, been aptly compared to that period, when the man, mellowed by age, yields the moſt valuable fruits of wiſdom and experience, but daily exhibits increaſing ſymptoms of decay. The cold, cheerleſs, and ſluggiſh Winter has, almoſt without a metaphor, been termed the decrepit and hoary old age of the year [c]. And Thomſon, whoſe noble poem is not merely a deſcriptive and philoſophical, but an eminently moral and religious one, has, from this view of his ſubject, deduced the moſt inſtructive leſſon.

Behold, fond Man!
See here thy pictur'd life; paſs ſome few years,
Thy flowering Spring, thy Summer's ardent ſtrength,
Thy ſober Autumn fading into age,
And pale concluding Winter comes at laſt,
And ſhuts the ſcene. Ah! whither now are fled
Thoſe dreams of greatneſs, thoſe unſolid hopes
Of happineſs, thoſe longings after fame,
Thoſe reſtleſs cares, thoſe buſy buſtling days,
Thoſe gay-ſpent feſtive nights, thoſe veering thoughts,
Loſt between good and ill, that ſhar'd thy life?
All now are vaniſh'd! Virtue ſole ſurvives,
Immortal never-failing friend of man,
His guide to happineſs on high.

The melancholy poet of the Night too, adducing the revolutions of Nature as evidences of the immortality of man, exhibits the following beautiful and inſtructive picture of the ſeaſons.

Look Nature through, 'tis revolution all;
All change, no death. Day follows night, and nigh
The dying day. Stars riſe, and ſet, and riſe.
Earth takes th' example: ſee, the Summer gay,

[c] See in particular Lucretius, v. 737; and Ovid, xv. 196.

With her green chaplet and ambroſial flowers,
Droops into pallid Autumn. Winter gray,
Horrid with froſt, and turbulent with ſtorm,
Blows Autumn and his golden fruits away,
Then melts into the Spring. Soft Spring, with breath
Favonian, from warm chambers of the ſouth,
Recalls the firſt. All, to reflouriſh, fades;
As in a wheel, all ſinks, to reaſcend:
Emblem of man, who paſſes, not expires.

XIX. ON SLEEP.

Somnus avaris
Inſerpit curis, pronuſque per aëra nutat,
Grata laboratæ referrens oblivia vitæ. STATIUS.

Sleep ſteals away
The wild deſires of men, and toils of day,
And brings, deſcending through the ſilent air,
A ſweet forgetfulneſs of human care. POPE.

MANKIND, without having recourſe to extraordinary events, muſt acknowledge the wiſdom and omnipotence of God, in a variety of inſtances, which, to an inattentive obſerver, ſeem of ſmall importance. The moſt common occurrences, the daily revolutions in nature, and in our own bodies, are alone ſufficient to enforce the ſtrongeſt conviction, that the world was created by an infinitely wiſe, powerful, and benevolent Being, who never ceaſes to govern and ſuperintend the whole. Of the infinite variety of wonders of which He is the author, one alone ſhall be the ſubject of my preſent diſcuſſion; and, although it occurs every day, it does not the leſs merit to be obſerved, and to be the object of admiration.

If every day did not produce freſh inſtances of the ingratitude of mankind, we might, perhaps, be at a loſs to know, why ſo liberal and impartial a benefactor as Sleep, ſhould meet with ſo few hiſtorians or panegyriſts. Writers, in general, are ſo totally abſorbed by the buſineſs of the day, as never to turn their attention to that power, whoſe officious hand ſo ſeaſonably ſuſpends the burden of life; and without whoſe interpoſition man would not be able to endure the fatigue of the moſt beneficial labour, or the ſtruggles of the moſt ſucceſsful oppoſition.

The poets, however, among all thoſe that enjoy the bleſſings of ſleep, ſeem to be exempted from this cenſure. How much Statius conſidered the evils of life as aſſuaged and ſoftened by the balm of ſlumber, we may diſcover by the pathetic invocation which he poured forth in his waking nights. Virgil and Milton call Sleep the gift of Heaven. Ovid has deified Sleep, and having given a beautiful deſcription of his houſe, makes Iris, the meſſenger of Juno, thus addreſs him:

Somne, quies rerum, placidiſſime Somne Deorum, &c.
LIB. XI.

O ſacred Reſt,
Sweet pleaſing Sleep, of all the powers the beſt!
O peace of mind, repairer of decay,
Whoſe balms renew the limbs to labours of the day,
Care ſhuns thy ſoft approach, and ſullen flies away!
DRYDEN.

Statius has likewiſe given a deſcription of the Houſe of Sleep; but Arioſto has not merely improved, but ſurpaſſed them both. Ovid, in particular, ſays there is no porter at the door; *Cuſtos in limine nullus.* But Arioſto has greatly enriched the picture, by placing Oblivion and Silence as centinels before it.

My readers will be pleaſed, perhaps, with ſome more poetical eulogies of Sleep:

O ſweet refreſhing Sleep! thou balmy cure
Of ſickneſs and of pain!
How has thy gentle power at length reliev'd me!
O ſoft oblivion of ſurrounding ills,
How grateful to th' afflicted are thy charms!
EURIP. by HUGHES.

Sleep, that knits up the ravell'd ſleeve of Care,
The death of each day's life, ſore Labour's bath,
Balm of hurt minds, great Nature's ſecond courſe,
Chief nouriſher in Life's feaſt! SHAKSPEARE.

Thou ſilent power, whoſe welcome ſway
Charms every anxious thought away;
In whoſe divine oblivion drown'd,
Sore Pain and weary Toil grow mild,
Love is with kinder looks beguil'd,
And Grief forgets her fondly-cheriſh'd wound;
O whither haſt thou flown, indulgent god?
God of kind ſhadows and of healing dews,
Whom doſt thou touch with thy Lethæan rod?
Around whoſe temples now thy opiate airs diffuſe?
AKENSIDE.

Haſte, haſte, ſweet ſtranger! From the peaſant's cot,
The ſhip-boy's hammock, or the ſoldier's ſtraw,
Whence Sorrow never chas'd thee; with thee bring
Not hideous viſions, as of late; but draughts
Delicious of well-taſted, cordial reſt;
Man's rich reſtorative; his balmy bath,
That ſupples, lubricates, and keeps in play
The various movements of this nice machine,
Which aſks ſuch frequent periods of repair. YOUNG.

And Caſa, in one of his ſonnets, with the uſual Italian aſſemblage of epithets, has this apoſtrophe:

O Sonno, O della queta, umida, ombroſa
Notte, placido figlio!

O Sleep, ſweet ſon of the peaceful, humid, umbrageous night!

In a word, to conclude, theſe inſtances of homage in the poets to "the downy god", Cowley, among the other felicities of his darling ſolitude, has not forgotten to number the privilege of ſleeping without diſturbance; and, among the gifts of Nature, he aſſigns a rank to the poppy, "which is ſcattered (ſays he) over the fields of corn, that all the needs of man may be eaſily ſatisfied, and that *bread* and *ſleep* may be found together".

How wonderful is it that a thinking being, who, in every diurnal revolution, experiences the ſweet and invigorating refreſhment of ſleep, ſhould never once reflect on his ſituation in thoſe moments of temporary inſenſibility; or, at leaſt, that he ſhould never conſider it as one of the moſt remarkable effects of the Divine Goodneſs! We have no ideas of any thing extraordinary, when ſleep ſpreads its ſoft and benevolent influence over us. We are content to imagine, that this machine, our body, is formed for that ſituation; and that the inclination which impels us to ſleep proceeds merely from natural cauſes. But ſleep, perhaps, may be conſidered in two points of view. On the one hand, there is nothing in it which does not neceſſarily reſult from our nature: on the other, there is ſomething ſo ſtriking and wonderful in this natural effect, that it is well worthy of the moſt minute examination.

It is certainly a proof of the wiſdom of our Creator, that we fall aſleep imperceptibly. Were we once to attempt to watch the moment when ſleep takes poſſeſſion of us, that very attempt would prove an obſtacle to its approach, and we could not ſleep while that idea was retained. Sleep comes unſummoned: it is the only change in our manner of exiſtence in which reflection bears no part; and the

more we endeavour to produce it, the leſs ſucceſsful ſhall we prove. The Divine Being, therefore, has ordained ſleep with ſuch a deſign, and in ſuch a manner, that it proves an agreeable neceſſity to all mankind; and he has rendered it alike independent of the underſtanding and of the will. Our ſituation, indeed, during the time of ſleep, is wonderful. We live; but we live without knowing, without perceiving it. The palpitations of the heart, the circulation of the blood, with digeſtion, and, in a word, all the animal functions, continue to be performed without interruption. The mind appears, as it were, to ſuſpend its activity, for a time: by degrees, it loſes all ſenſation, every diſtinct idea. The ſenſes are deadened, and ſtop their wonted operations. The muſcles, by degrees, are moved more ſlowly, till all voluntary motion ceaſes. This change begins in the forehead: then the muſcles of the eyelids, and of the neck, arms, and feet, are ſo much deprived of their activity, that the man ſeems to be metamorphoſed into a plant. The ſituation of the brain becomes ſuch, that it cannot tranſmit to the ſoul the ſame ideas as when we are awake. The ſoul perceives no object, although the nerve of viſion is not altered; and it would ſee nothing, were the eyes to be even open. The ears are not ſhut, and yet they hear nothing. In a word, thoſe who have leiſure to conſider the ſubject more minutely ſtill, by entering into anatomical inquiries concerning it, will find an unceaſing ſource of admiration, in the wonderful preparations, and the tender care, which the divine Being has employed, to procure us the bleſſings of ſleep.

There is ſomething in the approaches of ſleep ſo importunate and irreſiſtible, that it cannot long remain unſatisfied; and if, as ſome have done, we conſider it as the tax of life, we cannot but conſider it alſo as a tax that muſt be paid, unleſs we would ceaſe

to be men. On this account, Alexander the great declared, that nothing convinced him that he was not a divinity, but his not being able to live without ſleep.

Sleep is neceſſary to all men, in order to repair, and to invigorate again, both the intellectual and corporeal faculties, when exhauſted by long exertion and fatigue. It is neceſſary to the happy, to prevent ſatiety, and to endear life by a ſhort abſence; and to the miſerable, to relieve them by intervals of oblivion and repoſe. Such, indeed, is our frame, that, whether happy or miſerable, life is, to the greateſt part of mankind, ſuch as could not be endured without frequent intermiſſions of exiſtence.

Sleep has the ſame effect upon men, which night has upon colours: it reduces all to an equality. But, although it is the chief of all earthly bleſſings, it is not equally kind to all. It is juſtly appropriated to induſtry and temperance. Refreſhing reſt, and peaceful nights, are chiefly the portion of him who lies down weary with honeſt labour, and free from the fumes of indigeſted luxury. It is the juſt doom of indolence and gluttony, to be inactive without eaſe, and drowſy without repoſe. "The ſleep of the labouring man (ſays the Preacher) is ſweet, whether he eat little or much; but the abundance of the rich will not ſuffer him to ſleep".

Thoſe, who are not grateful for the unſpeakable bleſſing of ſleep, muſt be ſuch only that never knew the want of it. But how eaſy is it for diſeaſe, or grief, or infirmities, or old age, to deprive us of all the bleſſings of repoſe. Then ſhall we be compelled to acknowledge, that ſleep is at once the moſt urgent neceſſity of Nature, and the moſt ineſtimable bleſſing of Heaven. Shakſpeare, therefore, has finely contraſted the ſweets of a ſound ſleep and the horrors of a reſtleſs night, in this ſoliloquy of king Henry the fourth:

How many thouſands of my pooreſt ſubjects
Are at this hour aſleep! O gentle Sleep,
Nature's ſoft nurſe, how have I frighted thee,
That thou no more wilt weigh my eyelids down,
And ſteep my ſenſes in forgetfulneſs?
Why rather, Sleep, ly'ſt thou in ſmoky cribs,
Upon uneaſy pallets ſtretching thee,
And huſh'd with buzzing night-flies to thy ſlumbers,
Than in the perfum'd chambers of the great,
Under the canopies of coſtly ſtate,
And lull'd with ſounds of ſweeteſt melody?
O thou dull god, why ly'ſt thou with the vile
In loathſome beds, and leav'ſt the kingly couch
A watch-caſe, or a common larum-bell?
Wilt thou, upon the high and giddy maſt,
Seal up the ſhip-boy's eyes, and rock his brains
In cradle of the rude imperious ſurge;
And in the viſitation of the winds,
Who take the ruffian billows by the top,
Curling their monſtrous heads, and hanging them
With deaf'ning clamours in the ſlippery ſhrouds;
That, with the hurley, death itſelf awakes?
Canſt thou, O partial Sleep, give thy repoſe
To the wet ſeaboy in an hour ſo rude,
And in the calmeſt and the ſtilleſt night,
With all appliances and means to boot,
Deny it to a king? then happy low! lie down;
Uneaſy lies the head that wears a crown.

Nothing reſembles death ſo much as ſleep; and this reſemblance is ſo ſtriking and apparent, that ſleep has been called his brother, his half-brother, his image and his counterfeit.

O'er their brows death-counterfeiting ſleep
With leaden legs and batty wings doth creep.
SHAKSPEARE.

"Sleep (ſays ſir Thomas Browne) is ſo like death, that I dare not truſt it without my prayers, without bidding a half adieu unto the world, and taking a farewell in a colloquy with God".

Gratitude for a bleſſing ſo ineſtimable as ſleep ought certainly to prevent any rational being from abuſing it, by the extremes either of indulgence or of abſtinence. Not to enjoy the gifts of Heaven would beſpeak inſenſibility and ingratitude; but then he is to be cenſured, who, through indolence and ſloth, prolongs the hours deſtined to repoſe; and equally to be condemned is he, who from the incentives of avarice and ambition, or the love of pleaſure, deprives himſelf of a proper portion of that refreſhment which is ſo neceſſary to all. To ſay what that proper portion is, would be to invade, perhaps, the province of the phyſician; but Nature, in this reſpect, as well as every other, requires but little; and ſeven or eight hours of peaceful and uninterrupted ſleep, ſeem to be ſufficient; allowance being made for the difference of age and conſtitution.

So ineſtimable is the bleſſing of ſleep, that not only the poets, as I have obſerved before, but the ſacred ſcriptures, alſo, repreſent it as the gift of Heaven. "God giveth his beloved ſleep", ſays the Pſalmiſt; and Solomon obſerves, that to them who "keep ſound wiſdom and diſcretion" it is promiſed, that "their ſleep ſhall be ſweet". Conſiderations of this kind ſhould induce us to cultivate thoſe habits of piety and virtue, which are the only ſources of peace in life, and ſerenity in the hour of death; which can alone enable us to approach the divine Being, with humble hope and godly confidence, in the comfortable language of the Pſalmiſt: "I will both lay me down in peace and ſleep; for thou, Lord, only makeſt me dwell in ſafety". With ſentiments like theſe, replete with piety, if not with poetry, I ſhall conclude this paper:

Thou, whoſe nature cannot ſleep,
On my temples centry keep.
Sleep is a death; oh! make me try
By ſleeping what it is to die;

And as gently lay my head
In my grave as on my bed.
Howe'er I reſt, great God, let me
Awake again, at leaſt with thee;
And thus aſſur'd, behold I lie
Securely or to wake or die.
Theſe are my drowſy days; in vain
I do now wake to ſleep again;
O come that hour, when I ſhall never
Sleep again, but wake for ever. SIR T. BROWNE.

XX. ON DREAMS.

Et cui quiſque ferè ſtudio devinctus adhæret,
Aut quibus in rebus multùm ſumus morati,
Atque in quâ ratione fuit contenta magis mens,
In ſomnis eadem plerumque videmur obire.
LUCRETIUS.

And when ſoft ſleep the body lays at eaſe,
And from the heavy maſs the fancy frees,
Whate'er it is in which we take delight,
And think of moſt by day, we dream by night.
ANON.

FROM the conſideration of Sleep, which was the ſubject of my laſt paper, the tranſition is very natural to that of Dreams, the wonderful and myſterious phenomenons of that ſtate, the ideal tranſactions and vain illuſions of the mind. According to Wolfius, an eminent Sileſian philoſopher, every dream takes its riſe from ſome ſenſation, and is continued by the ſucceſſion of phantaſms in the mind. He obſerves, that when we dream, we imagine ſomething, or the mind produces phantaſms; but no phantaſm can ariſe in the mind without ſome previous ſenſation. And yet, it is not eaſy to confirm

this by experience; it being often difficult to diſtinguiſh thoſe ſlight ſenſations, which give riſe to dreams, from phantaſms, or objects of imagination [a]. —The ſeries of phantaſms, which thus conſtitute a dream, ſeem to be accounted for by the law of the imagination, or aſſociation of ideas; although it may be very difficult to aſſign the cauſe of every minute difference, not only in different ſubjects, but in the ſame, at different times, and in different circumſtances. And hence Formey, who adopts the opinion of Wolfius, concludes, that thoſe dreams are ſupernatural, which either do not begin by ſenſation, or are not continued by the law of the imagination [b].

This opinion is as old as Ariſtotle, who aſſerted, that a dream is only, the φαντασμα, or *appearance* of things, excited in the mind, and remaining after the objects are removed [c]. The opinion of Lucretius, in my motto, was likewiſe that of Tully [d]. Mr. Locke, alſo, traces the origin of dreams to previous ſenſations, and ſays, that the dreams of ſleeping men, are all made up of the waking man's ideas, though, for the moſt part, oddly put together [e]. And Dr. Hartley, who explains all the phenomenons of the imagination by his theory of vibrations and aſſociations, ſays, that dreams are nothing but the imaginations or reveries of ſleeping men, and that they are deducible from three cauſes, namely, the impreſſions and ideas lately received, and particularly thoſe of the preceding day; the ſtate of the body, particularly of the ſtomach and brain; and aſſociation [f].

Was I to enter more deeply into the ſubject of this myſterious phenomenon, my preſent lucubration

a Wolf. Pſychol. Empir. ſect. 123.

b Mem. de l'Acad. de Berlin, tom. ii, p. 316.

c De Inſomn. cap. 3.

d Quæ in vitâ uſurpant homines, cogitant, curant, vident, quæque agunt vigilantes, agitantque, ea cuique in ſomno accidunt. *De Div.*

e Eſſay on Human Underſtanding, book ii, chap. 1, ſec. 17.

f Obſervations on Man, vol. i, ſec. 5, p. 383.

would become too abſtruſe; and, after all, perhaps, no philoſophical nor ſatisfactory account can be given of it. Such of my readers, therefore, who would wiſh for a more minute inquiry into the opinions I have ſtated above, I muſt refer to the reſpective authors whom I have quoted.

From the ſcenes of nocturnal imagination, the reader, who is fond to find amuſement even in a ſerious ſubject, will be glad, perhaps, to be tranſported into the regions of poetical fiction. And here we find, that the Fancy is not more ſportive in dreams, than are the poets in their deſcriptions of her nocturnal vagaries.—I ſhall begin firſt with that admirable ſpeech in Romeo and Juliet, on the effects of the imagination in dreams:

O, then I ſee, queen Mab hath been with you.
She is the Fancy's midwife, and ſhe comes
In ſhape no bigger than an agat ſtone
On the fore finger of an alderman;
Drawn with a team of little atomies,
Athwart men's noſes as they lie aſleep:
Her waggon-ſpokes made of long ſpinners legs;
The cover, of the wings of graſshoppers;
The traces, of the ſmalleſt ſpider's web;
The collars, of the moonſhine's watry beams;
Her whip, of cricket's bone; the laſh, of film;
Her waggoner, a ſmall gray-coated gnat,
Not half ſo big as a round little worm,
Prickt from the lazy finger of a maid.
Her chariot is an empty hazel nut,
Made by the joiner ſquirrel, or old grub,
Time out of mind the fairies coachmakers:
And in this ſtate ſhe gallops night by night,
Thro' lovers brains, and then they dream of love;
On courtiers knees, that dream on curtſies ſtrait;
O'er lawyers fingers, who ſtrait dream on fees;
O'er ladies lips, who ſtrait on kiſſes dream,
Which oft the angry Mab with bliſters plagues,
Becauſe their breaths with ſweetmeats tainted are.

Sometimes ſhe gallops o'er a lawyer's noſe,
And then dreams he of ſmelling out a ſuit:
And ſometimes comes ſhe with a tithe-pig's tail,
Tickling the parſon as he lies aſleep;
Then dreams he of another benefice:
Sometimes ſhe driveth o'er a ſoldier's neck,
And then he dreams of cutting foreign throats,
Of breaches, ambuſcades, Spaniſh blades,
Of healths five fathom deep; and then anon
Drums in his ears, at which he ſtarts and wakes;
And being thus frighted, ſwears a prayer or two,
And ſleeps again.

Lucretius, in the verſes that immediately follow my motto, and Petronius, in his poem on the Vanity of Dreams, had preceded our immortal bard in a deſcription of the effects of dreams on different kinds of perſons. Both the paſſages, to which I allude, only ſerve to ſhow the vaſt ſuperiority of Shakſpeare's boundleſs genius: their ſenſe is thus admirably expreſſed by Stepney:

At dead of night, imperial Reaſon ſleeps,
And Fancy, with her train, her revels keeps.
Then airy phantoms a mix'd ſcene diſplay,
Of what we heard, or ſaw, or wiſh'd by day;
For Memory thoſe images retains
Which paſſion form'd, and ſtill the ſtrongeſt reigns.
Huntſmen renew the chaſe they lately run,
And generals fight again their battles won.
Spectres and furies haunt the murderer's dreams;
Grants and diſgraces are the courtier's themes.
The miſer ſpies a thief, or a new hoard;
The cit 's a knight; the ſycophant a lord.
Thus Fancy 's in the wild diſtraction loſt,
With what we moſt abhor, or covet moſt.
Honours and ſtate before this phantom fall;
For Sleep, like Death, its image, equals all.

Chaucer, in his tale of the Cock and Fox, has a fine deſcription, thus verſified by Dryden;

Dreams are but interludes which Fancy makes:
When monarch Reaſon ſleeps, this mimic wakes;
Compounds a medley of disjointed things,
A court of coblers, and a mob of kings:
Light fumes are merry, groſſer fumes are ſad:
Both are the reaſonable ſoul run mad;
And many monſtrous forms in ſleep we ſee,
That neither were, nor are, nor e'er can be.
Sometimes forgotten things, long caſt behind,
Ruſh forward in the brain, and come to mind.
The nurſe's legends are for truths received,
And the man dreams but what the boy believ'd.
Sometimes we but rehearſe a former play,
The night reſtores our actions done by day;
As hounds in ſleep will open for their prey.
In ſhort, the farce of dreams is of a piece,
Chimeras all; and more abſurd or leſs.

And Shakſpeare again:

I talk of dreams,
Which are the children of an idle brain,
Begot of nothing but vain phantaſy,
Which is as thin of ſubſtance as the air,
And more inconſtant than the wind.

Nor muſt Milton be omitted:

In the ſoul
Are many leſſer faculties, that ſerve
Reaſon as chief; among theſe Fancy next
Her office holds; of all external things,
Which the five watchful ſenſes repreſent,
She forms imaginations, aëry ſhapes,
Which Reaſon joining, or disjoining, frames
All what we' affirm, or what deny, or call
Our knowledge or opinion; then retires
Into her private cell, when Nature reſts.
Oft in her abſence mimic Fancy wakes,
To imitate her; but misjoining ſhapes,
Wild works produces oft, but moſt in dreams,
Ill matching words or deeds, long paſt or late.

From theſe poetical deſcriptions let us proceed to take a view of the principal phenomenons in dreaming. But I ſhall firſt give Mr. Locke's beautiful account of *Modes of Thinking*, as what will greatly illuſtrate the preceding obſervations:

"When the mind (ſays he) turns its view inward upon itſelf, and contemplates its own actions, *thinking* is the firſt that occurs. In it the mind obſerves a great variety of modifications, and thence receives diſtinct *ideas*. Thus the perception, which actually accompanies, and is annexed to any impreſſion on the body, made by an external object, being diſtinct from all other modifications of thinking, furniſhes the mind with a diſtinct idea, which we call *ſenſation*; which is, as it were, the actual entrance of an idea into the underſtanding by the ſenſes. The ſame idea, when it occurs again without the operation of the like object on the external ſenſory, is *remembrance*: if it be ſought after by the mind, and with pain and endeavour found, and brought again in view, it is *recollection*: if it be held there long under conſideration, it is *contemplation*: when ideas float in our minds without any reflection or regard of the underſtanding, it is that, which the French call *reverie*[a]; our language has ſcarce a name for it. When the ideas that offer themſelves (for as I have obſerved in another place, while we are awake, there

[a] There is a phenomenon in the mind, which, though it happens to us while we are perfectly awake, yet approaches the neareſt to ſleep of any I know. It is called the *reverie*, or, as ſome term it, the *brown ſtudy*, a ſort of middle ſtate between waking and ſleeping; in which, though our eyes are open, our ſenſes ſeem to be entirely ſhut up, and we are quite inſenſible of every thing about us, yet we are all the while engaged in a muſing indolence of thought, or a ſupine and lolling kind of roving from one fairy ſcene to another, without any ſelf-command; from which, if any noiſe or other accident rouſe us, we wake as from a real dream, and are often as much at a loſs to tell how our thoughts were employed, as if we had waked from the ſoundeſt ſleep. This is frequently called *dreaming*, ſometimes *abſence*, a thing often obſerved in lovers and people of a melancholy, or indeed ſpeculative turn. *Fordyce's Dial. on Education*, vol. ii, p. 255.

will always be a train of ideas ſucceeding one another in our minds) are taken notice of, and, as it were, regiſtered in the memory, it is *attention:* when the mind, with great earneſtneſs, and of choice, fixes its view on any idea, conſiders it on all ſides, and will not be called off by the ordinary ſolicitation of other ideas, it is what we call *intention*, or *ſtudy*. *Sleep* without dreaming is reſt from all theſe: and *dreaming* itſelf, is the having of ideas (while the outward ſenſes are ſtopped, ſo that they receive not outward objects with their uſual quickneſs) in the mind, not ſuggeſted by any external objects, or known occaſion, nor under any choice or conduct of the underſtanding at all; and whether that which we call *ecſtacy*, be not dreaming with the eyes open, I leave to be examined".

Dr. Beattie, in his Diſſertations Moral and Critical, has an ingenious eſſay on this ſubject, in which he attempts to aſcertain, not ſo much the *efficient*, as the *final* cauſes of this phenomenon, and to obviate thoſe ſuperſtitions in regard to it, which have ſometimes troubled weak minds. He labours, with great earneſtneſs, to ſhow, that dreams may be of uſe in the way of phyſical admonition; that perſons, who attend to them with this view, may make important diſcoveries with regard to their health; that they may be ſerviceable as the means of moral improvement; that, by attending to them, we may diſcern our predominant paſſions, and receive good hints for the regulation of them; that they may have been intended by Providence to ſerve as an amuſement to the mental powers; and that dreaming is not univerſal, becauſe, probably, all conſtitutions do not require ſuch an intellectual amuſement.—In obſervations of this kind we may diſcover the ingenuity of fancy and the ſagacity of conjecture: we may find amuſement in the arguments, but we look in vain for ſatisfaction. Nature, certainly, does nothing in vain; but I am far from thinking, that man is able,

in every caſe, to diſcover her intentions. Final cauſes, perhaps, ought never to be the ſubject of human ſpeculation, but when they are plain and obvious. To ſubſtitute vain conjectures, inſtead of the deſigns of Providence, on ſubjects where thoſe deſigns are beyond our reach, ſerves only to furniſh matter for the cavils of the ſceptical, and the ſneers of the licentious.

Among the many ſtriking phenomenons in our dreams, it may be obſerved, that, while they laſt, the memory ſeems to lie wholly torpid, and the underſtanding to be employed only about ſuch objects as are then preſented, without comparing the preſent with the paſt. When we dream, we often converſe with a friend who is either abſent or dead, without remembering that the ocean or the grave is between us. We float like a feather upon the wind; for we find ourſelves this moment in England, and the next in India, without reflecting that the laws of nature are ſuſpended, or inquiring how the ſcene could have been ſo ſuddenly ſhifted before us. We are familiar with prodigies; we accommodate ourſelves to every event however romantic; and we not only reaſon, but act upon principles, which are in the higheſt degree abſurd and extravagant. Our dreams, moreover, are ſo far from being the effect of a voluntary effort, that we neither know of what we ſhall dream, nor whether we ſhall dream at all.

But ſleep is not the only time in which ſtrange and unconnected objects involve our ideas in confuſion. Beſide the *reveries* of the day, of which I have already ſpoken, we have, in a moral view, our *waking dreams*, which are not leſs chimerical, and impoſſible to be realized, than the imaginations of the night.

Night viſions may befriend———
Our *waking* dreams are fatal. How I dreamt
Of things impoſſible! (Could ſleep do more?)
Of joys perpetual in perpetual change!

Of ſtable pleaſures on the toſſing wave!
Eternal ſunſhine in the ſtorms of life!
How richly were my noontide trances hung
With gorgeous tapeſtries of pictur'd joys!
Joy behind joy, in endleſs perſpective!
Till, at death's toll,———
Starting I woke, and found myſelf undone.

Sometimes, in our *ſleeping* dreams, we imagine ourſelves involved in inextricable woe, and enjoy, at waking, the ecſtaſy of a deliverance from it. "And ſuch a deliverance (ſays Dr. Beattie) will every good man meet with at laſt, when he is taken away from the evils of life, and awakes in the regions of everlaſting light and peace; looking back upon the world and its troubles, with a ſurpriſe and a ſatisfaction, ſimilar in kind (though far higher in degree) to that which we now feel, when we eſcape from a terrifying dream, and open our eyes to the ſweet ſerenity of a ſummer morning".—Sometimes, in our dreams, we imagine ſcenes of pure and unutterable joy; and how much do we regret, at waking, that the heavenly viſion is no more! But what muſt be the raptures of the good man, when he enters the regions of immortality, and beholds the radiant fields of permanent delight! The idea of ſuch a happy death, ſuch a ſweet tranſition from the dreams of earth to the realities of heaven, is thus beautifully deſcribed by Dryden, in his poem entitled Eleonora.

She paſſed ſerenely with a ſingle breath;
This moment perfect health, the next was death;
One ſigh did her eternal bliſs aſſure;
So little penance needs, when ſouls are almoſt pure.
As gentle dreams our waking thoughts purſue;
Or, one dream paſt, we ſlide into a new;
So cloſe they follow, and ſuch wild order keep,
We think ourſelves awake, and are aſleep;
So ſoftly death ſucceeded life in her:
She did but dream of heaven, and ſhe was there.

XXI. VERNAL REFLECTIONS.

Le doux Printemps revient, et ranime à la fois
Les oiſeaux, les zephirs, et les fleurs, et ma voix.
Dans les champs, dans les bois, ſur les monts d'alentour,
Que tout rit de bonheur, d'eſperance, et d'mour!

DE LILLE.

Lo! where the roſy-boſom'd Hours,
Fair Venus' train appear,
Diſcloſe the long-expecting flowers,
And wake the purple year!
The attic warbler pours her throat,
Reſponſive to the cuckow's note,
The untaught harmony of ſpring;
While, whiſp'ring pleaſure as they fly,
Cool zephyrs through the clear blue ſky
Their gather'd fragrance fling.

GRAY.

THE multiplicity of beautiful objects in the creation, and the variety and conſtant viciſſitude of the ſeaſons, are leſs to be wondered at by the Contemplative Philoſopher, than the inattention and indifference with which they are too often beheld. A rural excurſion is productive of very different reflections in ordinary minds from what wiſdom would ſuggeſt with admiration, and devotion utter with reverence and awe. Man, as if endowed with no higher faculties than the beaſts of the field, "wanders often with brute unconſcious gaze", and diſcerns not "the mighty Hand, that, ever buſy", upholds, informs, and actuates the whole.

What Tully has obſerved on a different occaſion, may be applicable likewiſe to all contemplations on the beauties of Nature and the Seaſons, and is a very forcible recommendation of them: *Omnia pro-*

fectò, cum ſe à cæleſtibus rebus referet ad humanas, excelſiùs magnificentiùſque et dicet et ſentiet: "The contemplation of celeſtial things will make a man both ſpeak and think more ſublimely and magnificently, when he deſcends to human affairs".—They have a tendency to exalt the mind above the low and groveling ideas that enſlave the vulgar, the prepoſſeſſions of ignorance, and the terrors of ſuperſtition. By a kind of philoſophical neceſſity, they ſuperinduce a habit of ſerious and devotional reflection, and, by a happy conſequence, a delight in the exerciſes of piety, benevolence, and virtue. They are productive, alſo, of the ſweeteſt and moſt permanent ſatisfaction; ſo well is philoſophy, in this reſpect, entitled to the noble eulogy of Milton:

How charming is divine philoſophy!
Not harſh and crabbed, as dull fools ſuppoſe,
But muſical as is Apollo's lute,
And a perpetual feaſt of nectar'd ſweets,
Where no crude ſurfeit reigns.

With the poets in every age Spring has been one of the moſt favourite ſubjects. When they would deſcribe the beauties of Paradiſe, and the felicities of the Golden Age, their Spring flouriſhes in perpetual verdure, and ſmiles with everlaſting pleaſure. Thus Milton adorns his Eden:

Airs, vernal airs,
Breathing the ſmell of field and grove, attune
The trembling leaves, while univerſal Pan,
Knit with the Graces and the Hours in dance,
Led on th' eternal Spring.

And Ovid deſcribes his Golden Age,

Ver erat æternum, placidique tepentibus auris
Mulcebant zephyri natos ſine ſemine flores.

The flow'rs unſown, in fields and meadows reign'd,
And weſtern winds immortal Spring maintain'd.

DRYDEN.

One of the moſt beautiful ornaments of poetry is the creation of imaginary beings, or the perſonification of inanimate objects. Such a favourite as the Spring could not, in courſe, be neglected or forgotten. It has been deſcribed as a youth of a moſt beautiful air and ſhape, but not yet arrived at that exact ſymmetry of parts, which maturer years might be ſuppoſed to give him. There is ſuch a bloom, however, in his countenance, with ſuch a ſweetneſs, complacency, and pleaſure, that he appears created to inſpire every boſom with delight. He is dreſſed in a flowing mantle of green ſilk, interwoven with flowers; a chaplet of roſes on his head, and a jonquil in his hand. Primroſes and violets ſpring up ſpontaneouſly at his feet, and all hature revives at his exhilerating aſpect. Flora attends him on one hand, and Vertumnus, in a robe of changeable ſilk, on the other. Venus, with no other ornament than her own beauties, follows after. She is ſucceeded by the Graces with their arms intwined, and with looſened girdles, moving to the ſound of ſoft muſic, and ſtriking the ground alternately with their feet. The Months that properly belong to this ſeaſon, appear likewiſe in his train, with ſuitable emblematic decorations.

Pleaſure is repreſented as taking her flight in Winter to cities and towns, and reviſiting the gladdened country in Spring. Mrs. Barbauld has beautifully deſcribed this, as well as the gradual progreſs of the ſeaſon, from its earlieſt infant efforts, to the perfection of vernal beauty in the delightful month of May.

When Winter's hand the roug'ning year deforms,
And hollow winds foretel approaching ſtorms,
Then Pleaſure, like a bird of paſſage, flies
To brighter climes, and more indulgent ſkies;
Cities and courts allure her ſprightly train,
From the bleak mountain and the naked plain;

And gold and gems with artificial blaze,
Supply the ſickly ſun's declining rays.
But ſoon, returning on the weſtern gale,
She ſeeks the boſom of the graſſy vale:
There, wrapt in careleſs eaſe, attunes the lyre,
To the wild warblings of the woodland quire:
The daiſied turf her humble throne ſupplies,
And early primroſes around her riſe.

* * * * *

Now the glad earth her frozen zone unbinds,
And o'er her boſom breathe the weſtern winds.
Already now the ſnowdrop dares appear,
The firſt pale bloſſom of th' unripen'd year;
As Flora's breath, by ſome transforming pow'r,
Had chang'd an icicle into a flow'r:
Its name and hue the ſcentleſs plant retains,
And winter lingers in its icy veins.
To theſe ſucceed the violet's duſky blue,
And each inferior flow'r of fainter hue;
Till riper months the perfect year diſcloſe,
And Flora cries, exulting, See my roſe.

What a wonderful revolution, indeed, in the univerſal aſpect of Nature does the return of this lovely ſeaſon exhibit! After having been long bound up with froſt, or overſpread with ſnow, the earth once more diſplays all her variety of plants and flowers, is arrayed with the moſt beautiful and enlivening verdure, variegated with a numberleſs variety of hues, and exhales odours ſo exquiſitely pure and fragrant, that every ſenſe of every creature is awake to inexpreſſible delight.

Forth in the pleaſing Spring
His beauty walks, His tenderneſs and love.
Wide flush the fields; the ſoftening air is balm;
Echo the mountains round; the foreſt ſmiles;
And every ſenſe, and every heart is joy. THOMSON.

None of the other ſeaſons can vie with Spring in lovelineſs and amenity. It has the ſame order

among them that the morning has among the diviſions of the day, and youth among the ſtages of life. It may be called the favourite ſeaſon of harmony; for the warbling of the feathered tribes has been obſerved to have now a peculiar wildneſs and ſweetneſs of melody. Nor is its ſweet influence confined to the ſongſters of the groves: it pervades the whole animal creation. But I muſt confine my obſervations to its influence on man, that I may not be led to exceed the limits of this paper. Thomſon, in his inimitable Seaſons, has left nothing on this ſubject for future poets to deſcribe.

In the opening of Spring, and the ſubſequent renovation of Nature, how very ſenſibly is the human ſoul exhilerated by that ſenſe of pleaſure, which inſpires the birds with melody, and the whole creation with joy. In this ſeaſon, when we contemplate the ſmiling ſcenes around, thoſe ſecret overflowings of gladneſs are diffuſed over the ſoul, which compoſe what Milton expreſſively calls "vernal delight", and which I have heard denominated, with no leſs beauty and propriety, "the ſmile of Nature". What an exquiſite ſenſe of this does the virtuous philoſopher experience! The creation, particularly in this lovely ſeaſon, is a perpetual feaſt to the mind of a good man. From all that he beholds, he receives inſtruction and delight. Providence has adorned the whole creation with ſuch a variety of beautiful and uſeful objects, that it is impoſſible for a mind, not imbruted by mere ſenſual enjoyments, to contemplate the ſcenes around without ſome of the ſweeteſt internal ſenſations of which man can be ſuſceptible. But when to the delightful ſatisfaction which rural objects afford, we add an occaſional attention to the ſtudies of natural philoſophy, our reliſh for the beauties of the creation is quickened, and rendered not only pleaſing to the imagination, but to the underſtanding; and it is an unqueſtionable

truth, that the man who extends his inquiries into the works of Nature, multiplies, in ſome degree, the inlets to happineſs. The philoſopher is not content with the lulling murmur of brooks, or the enlivening melody of birds, with the ſhade of imbowering woods, the verdure of fields, or the embroidery of meadows. He will reflect, on the contrary, on the infinite variety of benevolent purpoſes to which they are all ſubſervient, and the wonders of that Divine Wiſdom of which they all exhibit ſuch impreſſions. While the pleaſures of the eye, in courſe, are heightened, his ſoul is exalted to that rational admiration, which inſenſibly leads to love and adoration; and while he "walks ſuperior amid the glad creation, muſing praiſe, and looking lively gratitude", with a kind of ſacred ecſtaſy he exclaims,

Theſe are thy glorious works, Parent of Good,
Almighty, Thine this univerſal frame,
Thus wondrous fair: Thyſelf how wondrous then
Unſpeakable! MILTON.

While unuſual ſweetneſs thus inſpires the whole creation with a purer joy, the moral philoſopher is led to inquire into the natural effects of this delightful influence, not only on the frame, but on the heart of man. The affections, he is fond to imagine, are all attuned to benevolence, and each diſcordant paſſion ſoothed to ſerenity and peace. This beautiful idea is adopted by Thomſon:

Can fierce paſſions vex his breaſt,
While every gale is peace, and every grove
Is melody?

With what a generous ſatisfaction too will Humanity reflect on the reſtorative effects of Spring! The convaleſcent, ſo lately wretched, ſo long oppreſſed by the heavy load of pain, and languor, and

diſeaſe, now feel, as it were, a new creation; and ſweet are the cheering ſenſations, ſweet the unwonted joys, that now recall them to the exertions of ſtrength and the happineſs of health.

Fair the face of Spring,
When rural ſongs and odours wake the morn
To every eye; but how much more to his
Round whom the bed of ſickneſs long diffus'd
Its melancholy gloom! How doubly fair,
When firſt with freſh-born vigour he inhales
The balmy breeze, and feels the bleſſed ſun
Warm at his boſom, from the ſprings of life
Chaſing oppreſſive damps and languid pain!

AKENSIDE.

But as the human mind is not univerſally the ſame, the renovation of ſpring ſheds not on all alike its enlivening influence. Some perſons, at times, experience ſenſations very different from that gayety which is ſuppoſed to be inſeparable from the vernal ſeaſon. Amid the bright verdure of the earth, the gay variety of trees and flowers, and the ſerenity of the blue concave, a kind of tranquil melancholy enters into all their ſolitary moments, which the beauties of the landſcape, and the melody of the birds, will rather ſooth than overcome. Among the various reaſons that may be given for the occurrence of ſuch penſive ideas, is the recollection, perhaps, that the ſpring brings back with it the remembrance, but not the return of our youthful ſcenes of hilarity and ſtrength; and that while Nature, in regular viciſſitude, is renewed in youth and beauty, man haſtes apace to that wintry ſtate of infirmity and decrepitude, when the brighteſt ſpring muſt ceaſe to charm, and life itſelf expire, under the preſſure of accumulated years. Indulging ſuch ſentiments as theſe, one may be diſpoſed to addreſs Spring in the words of Mirtillo, in the Paſtor Fido

of Guarini, the turn of which has been ſo beautifully copied by Milton [a].

O Primavera, gioventù dell' anno,
Bella madre di fiori,
D'erbe novelle, e di novelli amori;
Tu torni ben, ma teco
Non tornano i ſereni
E fortunati dì delle mie gioge.

Parent of blooming flowers and gay deſires,
Youth of the tender year, delightful Spring
* * * * *
Again doſt thou return, but not with thee,
Return the ſmiling hours I once poſſeſs'd.

LYTTLETON.

Let then conſiderations of this kind inculcate ſome uſeful leſſon, and they may, at times, be innocently, if not too frequently, indulged. Let them teach the young and gay the neceſſity of making uſe, at the ſame time, of the ſpring of the year and the ſpring of life; of acquiring, while their minds may be yet impreſſed with new images, the love of innocent enjoyments, and a paſſion for uſeful and virtuous wiſdom. In fine, let them remember, as a fine writer has expreſſed it, "that a blighted ſpring makes a barren year, and that the vernal flowers, however beautiful and gay, are only introduced by Nature as preparatives for autumnal fruits".

To perſons advanced in life, true wiſdom will not fail to adminiſter the nobleſt motives for manly conſolation and rejoicing hope. A good man will reflect, that ſince it is impoſſible for his declining years to return to their firſt ſpring of health and vigour, it

[a] Thus with the year
Seaſons return, but not to me returns
Day, or the ſweet approach of ev'n or morn,
Or ſight of vernal bloom, or ſummer's roſe,
Or flocks, or herds, or human face divine.

is yet in his power to ſoften the inconveniences he may feel, by the cultivation of ſuch virtues, and the enjoyment of ſuch pleaſures, as have a natural tendency to produce an eaſy and contented mind. Taught to look into himſelf, he will wiſely reflect on the vanity of ſetting his heart on external enjoyments. He will feel nothing of that unſocial diſpoſition which the gloom of auſterity excites. On the contrary, a penſive tenderneſs, a ſerene but not unpleaſing melancholy, will be diffuſed over his ſoul, inſpiring the ſweet tranquillity of benevolence, yet awake, at the ſame time, to all the active energy of goodneſs. Hence the charms of virtuous life, and of a devout intercourſe with the God of Seaſons, "the Great Arbiter of life and death": For he knows "that his Redeemer liveth, and that he ſhall ſtand at the latter day upon the earth; and though after his ſkin worms deſtroy his body, yet in his fleſh ſhall he ſee God". Hence he looks forward, not merely with a ſerenity of ſoul, but with the aſpirations of piety, and the triumph of anticipating faith: he looks forward to that bliſsful period, when the viciſſitude of ſeaſons ſhall be no more; when "the ſpirits of the juſt made perfect" ſhall enjoy the ſociety of angels and archangels, reſplendent in celeſtial beauty, and happy in perpetual ſpring.

XXII. A MOONLIGHT SCENE.

Lucidum cœli decus—
Siderum regina— HORACE.

The beauty of heaven, the glory of the ſtars.
SON OF SIRACH.

THERE are certain great and magnificent objects in the creation, the contemplation of which

has a tendency to produce a kind of internal elevation and expanſion; to raiſe the mind above its ordinary ſtate; and to excite a degree of wonder and aſtoniſhment, which it cannot often expreſs. The emotion is certainly delightful; but it is entirely of the ſerious kind; and it is attended, moſt commonly, by a degree of ſolemnity and awe, very different from the ſprightly ſenſations inſpired by ſcenes, that glow, as it were, with exceſſive radiance and overpowering beauty.

The ſcenes, indeed, which are moſt calculated to inſpire "ſublimities of thought", are not ſo much the ſmiling landſcape, the variegated fields, and dazzling ſkies, as the venerable woods, the high-impending cliff, or the headlong torrent. Hence too, nocturnal views are commonly the moſt ſublime. The firmament, filled with ſtars, that are ſcattered through infinite ſpace, with ſuch magnificent profuſion, impreſſes the imagination with ideas far more grand and awful, than when we view it enlightened by all the ſplendour of the ſun. Of this ſentiment is our favourite poet of the Night:

And ſee, Day's amiable Siſter ſends
Her invitation, in the ſofteſt rays
Of mitigated luſtre; courts thy ſight,
Which ſuffers from her tyrant brother's blaze.
Night grants thee the full freedom of the ſkies,
Nor rudely reprimands thy lifted eye—
Night opes the nobleſt ſcenes, and ſheds an awe,
Which gives thoſe venerable ſcenes full weight,
And deep reception in th' intender'd heart.

The objects, moreover, which the eye contemplates by day, do not affect the penſive mind with a pleaſure ſo ſerene, if I may ſo expreſs myſelf, as the milder glories of a moonlight evening. We then behold a new picture of things, which is more delicately ſhaded, and diſpoſed into ſofter lights, than

that which the radiant ruler of the day had before diſplayed. Each tumultuous care and important agitation has vaniſhed with "the gariſh eye of day". The diſcordant paſſions are ſoothed into ſerenity and peace, by the ſtillneſs of all around. In this happy moment, we imbibe, as it were, the univerſal repoſe of Nature; for there is not an object but ſeems to be at reſt; and the muſing wanderer can ſcarce forbear to exclaim with Lorenzo,

How ſweet the moonlight *ſleeps* upon this bank [a]!

The greateſt poets in every age have vied with each other in the deſcription of a moonlight evening. But, among all the treaſures of ancient and modern poetry, I know not one ſuperior, for pleaſing imagery, and variety of numbers, than that of Milton:

Now came ſtill Evening on, and Twilight gray
Had in her ſober livery all things clad;
Silence accompanied; for beaſt and bird,
They to their graſſy couch, theſe to their neſts,
Were ſlunk, all but the wakeful nightingale;
She all night long her amorous deſcant ſung;
Silence was pleas'd: now glow'd the firmament
With living ſaphirs: Heſperus, that led
The ſtarry hoſt, rode brighteſt, till the Moon,
Riſing in clouded majeſty, at length,
Apparent queen, unveil'd her peerleſs light
And o'er the dark her ſilver mantle threw.

I can recollect only one deſcription that is worthy to be mentioned after this. It is of a fine moonſhiny night, by way of ſimile, in the eighth book of the Iliad. It is eſteemed, indeed, a maſterpiece of nocturnal painting. But Milton's deſcription, it muſt be obſerved, leaves off where that of Homer begins:

[a] Merchant of Venice, act v.

As when the Moon, refulgent lamp of night,
O'er heav'n's clear azure ſheds her ſacred light,
When not a breath diſturbs the deep ſerene,
And not a cloud o'ercaſts the ſolemn ſcene,
Around her throne the vivid planets roll,
And ſtars unnumber'd gild the glowing pole;
O'er the dark trees a yellower verdure ſhed,
And tip with ſilver every mountain's head;
Then ſhine the vales, the rocks in proſpect riſe,
A flood of glory burſts from all the ſkies:
The conſcious ſwains, rejoicing in the ſight,
Eye the blue vault, and bleſs the uſeful light. POPE.

Nor have the ſacred writers been unobſervant of this bright "ſovereign of the ſhades".[a] The patriarch Job obſerves, that he could behold "the moon walking in brightneſs", without being ſeduced to the adoration of aught but the great Creator of the univerſe. And the Pſalmiſt, from a view of the nocturnal heavens, expreſſes himſelf in the moſt reverential language of aſtoniſhment and humility: "When I conſider the heavens, the work of thy fingers; the moon and the ſtars, which thou haſt ordained; what is man that thou art mindful of him, and the ſon of man that thou viſiteſt him?"—Nor muſt we omit to mention again the wiſe Son of Sirach, although his writings are not admitted into the ſacred canon: "The Lord made the moon alſo to ſerve in her ſeaſon, for a declaration of times, and a ſign of the world. From the moon is the ſign of feaſts, a light that decreaſeth in her perfection. The month is called after her name, increaſing wonderfully in her changing, being the inſtrument of the armies above, ſhining in the firmament of heaven; *the beauty of heaven, the glory of the ſtars*, an ornament giving light to the higheſt places of the Lord. At the command of the Holy One they will ſtand in their order, and never faint in their watches".—

[a] Nemorumque potens Diana. HORACE.

This is paraphraſed with great elegance and ſpirit by Mr. Broome, the honoured and not unequal co-adjutor of Pope, in his poetical verſion of the Odyſſey:

By Thy command the Moon, as daylight fades,
Lifts her broad circle in the deep'ning ſhades;
Array'd in glory, and enthron'd in light,
She breaks the ſolemn terrors of the night;
Sweetly inconſtant in her varying flame,
She changes ſtill, another, yet the ſame!
Now in decreaſe, by ſlow degrees ſhe ſhrouds
Her fading luſtre in a veil of clouds;
Now of increaſe, her gathering beams diſplay
A blaze of light, and give a paler day;
Ten thouſand ſtars adorn her glittering train,
Fall when ſhe falls, and riſe with her again;
And o'er the deſerts of the ſky unfold
Their burning ſpangles of ſidereal gold:
Through the wide heavens ſhe moves ſerenely bright,
Queen of the gay attendants of the night;
Orb above orb in ſweet confuſion lies,
And with a bright diſorder paints the ſkies.

But this noble ſubject is not monopolized by the poets: it affords ample room for inquiry to the Contemplative Philoſopher. Of all the celeſtial orbs, the Moon, next to the Sun, has the moſt beneficial influence upon our globe. And if her beautiful appearance in the ſkies, with ſuch regular and conſtant variations, were inſufficient to attract our attention, ſhe would at leaſt inſpire us with the warmeſt ſentiments of gratitude and adoration toward the beneficent Being, who has formed and ſtationed her in ſuch a manner, as to be productive of the moſt ſignal advantages to the Earth.

By the naked eye we can diſcover many of the moſt remarkable phenomenons that diſtinguiſh the Moon from the innumerable orbs around her. We find her to be only a ſecondary planet, or attendant

upon the Earth, revolving round it, from change to change, in twenty-nine days, twelve hours, and forty-four minutes, and accompanying its circuit round the Sun in the ſpace of our year. Her diameter is 2180 miles, and her diſtance from the centre of the earth 240,000. She goes round her orbit in twenty-ſeven days, ſeven hours, and forty-three minutes, moving at the rate of 2290 miles every hour; and ſhe turns round her axis exactly in the ſame time that ſhe revolves round the Earth, which is the reaſon of her keeping always the ſame ſide toward us, and that her day and night, taken together, is as long as our lunar month.

The Moon, like the Earth, is an orbicular and opaque body, which ſhines only by reflecting the Sun's light. While that half of her, therefore, which is toward the Sun, is illuminated, the other half is dark and inviſible. Hence, ſhe diſappears when ſhe comes between the Earth and the Sun: becauſe her dark ſide is then toward us. When ſhe is gone ſomewhat forward, we ſee a little of her enlightened ſide, which ſtill increaſes to our view, as ſhe advances forward, until ſhe comes to be oppoſite the Sun, where her entire enlightened ſide is toward the Earth, and ſhe appears with a full illuminated orb, which we call the Full Moon; her dark ſide being then turned away from the Earth. From the full ſhe decreaſes gradually as ſhe proceeds through the other half of her courſe; ſhowing us leſs and leſs of her bright ſide every day, till her next change or conjunction with the Sun, and then ſhe diſappears as before. Theſe different appearances having been obſerved by Endymion, an ancient Grecian, who watched her motions, it gave riſe to the fable of Diana falling in love with him.

Theſe different appearances of the Moon, which we call her Phaſes, are ſufficient to demonſtrate, that ſhe ſhines not by any light of her own; for

otherwiſe, as her form is ſpherical, we ſhould always behold her, like the Sun, with a full orb.

Philoſophers, moreover, have obſerved, that one half of the Moon has no darkneſs at all; the Earth conſtantly affording it a ſtrong light, in the abſence of the Sun; while the other half has alternately a fortnight's darkneſs and a fortnight's light. Our Earth ſerves as a moon to the Moon, waxing and waning regularly, but appearing thirteen times as large, and affording her thirteen times as much light as ſhe does to us. When ſhe changes to us, the Earth appears full to her; when ſhe is in her firſt quarter to us, the Earth is in its third quarter to her; and *vice verſâ*.

The Moon has no viſible atmoſphere, of any denſity, ſurrounding her, as we have; for if ſhe had we could never ſee her edge ſo well defined as it appears; but there would be a ſort of miſt or hazineſs about her, which would make the ſtars look fainter when they are ſeen through it. But it has been proved by obſervation, that the ſtars which diſappear behind the Moon, retain their full luſtre, until they ſeem to touch her very edge, when they vaniſh in an inſtant. Nor can there be any ſeas in the Moon; for if there were, ſhe could have no clouds, nor rains, nor ſtorms, as we have; becauſe ſhe has no ſuch atmoſphere to ſupport the vapours which occaſion them. And it is apparent to all, that when the Moon is above our horizon in the nighttime, ſhe is viſible, unleſs the clouds of our atmoſphere hide her from our view; and every part of her appears conſtantly with the ſame ſerene and unclouded aſpect. Thoſe dark parts of the Moon, which were formerly thought to be ſeas, are now found to be only vaſt and deep cavities, and places which reflect not the light of the Sun ſo ſtrongly as others. For, by obſervations through the teleſcope, the Moon has been found to be full of high mountains and deep

vallies; and ſome of theſe mountains, by comparing their height with the diameter of the Moon, are found to be three times higher than the higheſt hills upon our Earth.

Such are the principal phenomenons that diſtinguiſh this beautiful luminary. And if we advert to the ſignal benefits of which it is productive to our globe, we can never be ſufficiently grateful to the omnipotent Creator, who in this, as well as in all his works, has diſplayed infinite wiſdom and inexhauſtible goodneſs. How cheerleſs and uncomfortable would be our nights, but for the conſtant returns of light, which this our ſiſter orb, our faithful and inſeparable companion, diſpenſes in ſuch agreeable viciſſitude! How highly uſeful are even her eclipſes, in our aſtronomical, geographical, and chronological calculations! How ſalutary too is her attractive influence, which ſways the ocean, and actuates the world of waters; which ſwells the tides, and perpetuates the regular returns of ebb and flow; and which thus not only preſerves the liquid element itſelf from putrefaction, but the ſurrounding continents, in courſe, from infection and diſeaſe.

I will not here urge thoſe ſentiments of devotion, thoſe grand and auguſt conceptions, which this ſubject has a tendency to inſpire. Yet not wholly to conclude this paper without a moral, I will juſt intimate to my fair readers, that Mr. Pope, from the mild and ſerene appearance of the Moon, contraſted to the dazzling brightneſs of the Sun, exhibits a beautiful compariſon, and a portrait, not leſs beautiful, of an eſtimable woman. This, I am perſuaded, will inculcate a leſſon, which, if properly attended to by the fair, cannot fail to heighten and perpetuate every charm:

Ah! friend, to dazzle let the vain deſign;
To raiſe the thought, and touch the heart be thine!
That charm ſhall grow, while what fatigues the ring,
Flaunts and goes down, an unregarded thing:

So when the ſun's broad beam has tir'd the ſight,
All mild aſcends the moon's more ſober light;
Serene in virgin modeſty ſhe ſhines,
And unobſerv'd the glaring orb declines.
Oh! bleſt with temper, whoſe unclouded ray
Can make to-morrow cheerful as to-day:
She, who can love a ſiſter's charms, or bear
Sighs for a daughter with unwounded ear;
She, who ne'er anſwers till a huſband cools,
Or if ſhe rules him, never ſhows ſhe rules;
Charms by accepting, by ſubmitting ſways,
Yet has her humour moſt, when ſhe obeys;
Let ſops of fortune fly which way they will,
Diſdains all loſs of tickets or codille;
Spleen, vapours, or ſmallpox, above them all,
And miſtreſs of herſelf, though china fall.

XXIII. REFLECTIONS ON DEW.

Non liquidi gregibus fontes, non gramina deerunt:
Et quantum longis carpent armenta diebus,
Exigua tantem gelidus ros nocte reponet. VIRGIL

There, for thy flocks, freſh fountains never fail;
Undying verdure clothes the graſſy vale;
And what is cropt by day the night renews,
Shedding refreſhful ſtores of cooling dews.
J. WARTON.

Who hath begotten the drops of dew? JOB.

THERE is not a phenomenon of Nature more common, nor more beautiful than that of Dew. The poets in courſe have ſeized it with avidity, to decorate their favourite-themes, and particularly their deſcriptions and perſonifications of the Morning. But I do not recollect that the venerable ſire of poetry, who abounds in theſe, has once enriched them by any alluſions to dew. Indeed, in Pope's Tranſla-

tion of the Iliad and Odyſſey, there are three different paſſages, in which Aurora ſprinkles the *dewy* lawn with light [a]. But this is the embelliſhment of the tranſlator; for in neither of theſe paſſages, is the epithet *dewy* in the original.

Homer, however, has not forgotten the dews, in that variety of beautiful decorations with which he deſcribes the bed of Jupiter:

Celeſtial dews, deſcending o'er the ground,
Perfume the mount, and breathe ambroſia round.
POPE.

But Milton gives them more importance:-he introduces them into his deſcriptions with a peculiar felicity:

Now Morn her roſy ſteps in th' eaſtern clime
Advancing, *ſow'd the earth with orient pearl.*

This fine metaphor of *ſowing the earth* has been before uſed by Lucretius:

Sol etiam ſummo de vertice diſſipat omnes
Ardorem in partes, et *lumine conſerit arva.*

The ſun, reſplendent, at his noontide height,
Shines forth, and *ſows the fields with dazzling light,*

But this wants much of the propriety of Milton's *ſowing the earth with orient pearl*; for the dew-drops have unqueſtionably ſomething of the ſhape and appearance both of ſcattered ſeeds and ſparkling gems.

But our divine bard, in ſpeaking of the prodigious hoſt of Satan, has introduced dew into a moſt beautiful ſimile:

an hoſt,
Innumerable as the ſtars of night,
Or *ſtars of morning, dew-drops, which the ſun*
Impearls on every leaf and every flower.

[a] Pope's Iliad, viii, 1. xxiv, 1000. and Odyſſey xvii, 1.

Innumerable as the ſtars is an old ſimile; but this of the ſtars of morning, dew-drops, ſeem as new as it is beautiful. And the ſun impearls them; that is turns them by his reflected beams to ſeeming pearls, as the morn was ſaid above to ſow the earth with orient pearl.

A favourite compariſon with our Engliſh poets is that of tears to dew, or of dew to tears. Thus Shakſpeare:

And that ſame *dew*, which ſometime on the buds
Was wont to ſwell like round and orient pearls,
Stood now within the pretty flow'ret's eyes,
Like *tears* that did their own diſgrace bewail.

In Samſon Agoniſtes, when Dalilah comes to viſit her eyeleſs huſband, ſhe is afraid to approach; and Milton has made her ſilence moſt beautifully expreſſive: the Chorus tells Samſon,

Yet on ſhe moves, now ſtands, and eyes thee fix'd,
About t' have ſpoke, but now, with head declined,
Like a fair flower ſurcharg'd with dew, ſhe weeps,
And words addreſs'd ſeem into tears diſſolv'd,
Wetting the borders of her ſilken veil.

In Virgil, the *Ros in tenera pecori gratiſſimus herba —the dew on the tender graſs grateful to the cattle*, is rendered by Dryden *the pearly drops of morning dews*, and by Dr. Warton *the Morning's earlieſt tears*. Nor has Pope neglected them in his Elegy to the Memory of an unfortunate Lady:

Yet ſhall thy grave with riſing flowers be dreſt,
And the green turf lie lightly on thy breaſt:
There *ſhall the Morn her earlieſt tears beſtow*,
There the firſt roſes of the year ſhall blow.

And moſt of my readers will recollect the celebrated couplet of Lord Cheſterfield, in his Advice to a Lady in Autumn:

The dews of the evening moſt carefully ſhun;
Thoſe *tears of the ſky* for the loſs of the ſun.

Gray, in his Elegy in a Country Churchyard, exhibits a fine picture of a melancholy man:

Haply ſome hoary-headed ſage may ſay,
"Oft have we ſeen him at the peep of dawn,
Bruſhing with haſty ſteps the dews away,
To meet the ſun upon the upland lawn".

But I muſt now leave the pleaſing entertainment of poetry, to attend to the more inſtructive diſcuſſions of philoſophy.—The Dew is generally ranked by naturaliſts among the aqueous meteors, thoſe bodies that exiſt in the atmoſphere in a flux and tranſitory ſtate. It is a denſe, moiſt vapour, found upon the earth in ſpring and ſummer mornings, in the form of a miſling rain, and it is chiefly collected while the ſun is below the horizon.

It has been diſputed whether dew is formed from the vapours *aſcending* from the earth during the nighttime, or from the *deſcent* of ſuch as have been already raiſed through the day. The moſt remarkable experiments, adduced in favour of the firſt hypotheſis, are thoſe of M. Dufay, of the Royal Academy of Sciences at Paris. He ſuppoſed, that if dew aſcended, it muſt wet a body placed low down ſooner than one placed in a higher ſituation; and, if a number of bodies were placed in this manner, the lowermoſt would be wetted firſt; and the reſt in like manner, gradually up to the top.

To determine this, he placed two ladders againſt one another, meeting at their tops, ſpreading wide aſunder at the bottom, and ſo tall as to reach thirty-two feet high. To the ſeveral ſteps of theſe he faſtened large ſquares of glaſs like the panes of windows, placing them in ſuch a manner, that they ſhould not overſhade one another. On the trial it appeared exactly as M. Dufay had apprehended. The

lower ſurface of the loweſt piece of glaſs was firſt wetted, then the upper, then the lower ſurface of the pane next above it; and ſo on, till all the pieces were wetted to the top. Hence it appeared plain to him, that dew conſiſted of the vapours aſcending from the earth during the nighttime; which, being condenſed by the coldneſs of the atmoſphere, are prevented from being diſſipated as in the daytime by the ſun's heat. He afterward tried a ſimilar experiment with pieces of cloth, inſtead of panes of glaſs, and the reſult was quite conformable to his expectations. He weighed all the pieces of cloth the next morning, in order to know what quantity of water each had imbibed, and found thoſe that had been placed lowermoſt conſiderably heavier than ſuch as had been placed at the top; although he confeſſes that this experiment did not ſucceed ſo perfectly as the former.

M. Muſchenbroek, who embraced the contrary opinion, thought he had invalidated all M. Dufay's proofs, by repeating his experiments with the ſame ſucceſs, on a plane covered with ſheet-lead. But to this M. Dufay replied, that there was no occaſion to ſuppoſe the vapour to riſe through the lead, nor from that very ſpot; but that as it aroſe from the adjoining open ground, the continual fluctuation of the air could not but ſpread it abroad, and carry it thither in its aſcent.

But although M. Muſchenbroek's experiment is not ſufficient to overthrow thoſe of M. Dufay, it muſt ſtill remain dubious whether dew riſes or falls. One thing, which ſeems to favour the hypotheſis of its deſcent is, that in cloudy weather there is little or no dew to be obſerved. From this, M. de Luc brings an argument in favour of the laſt hypotheſis, the deſcent of dew; and he accounts for it in the following manner: when there are no clouds in the air, the heat of the inferior air and of that which riſes

from the earth, is diſſipated into the ſuperior regions; and then the vapours, which are diſperſed throughout the air, condenſe, and fall down in dew. But when the clouds continue, they ſeparate the inferior from the ſuperior part of the atmoſphere, and thus prevent the diſſipation of the heat, by which means the vapours remain ſuſpended. When the ſky grows cloudy, ſome hours after ſunſet, although the heat has been ſenſibly diminiſhed; it is again increaſed; becauſe, continuing to riſe out of the earth, it is accumulated in the inferior air.—But neither can this be deemed a poſitive proof of the deſcent of dew; ſince we may as well ſuppoſe the heat of the atmoſphere to be great enough to diſſipate it in its aſcent, as to keep it ſuſpended after its aſcent through the day.

On the other hand, its being found in greater quantities on bodies placed low down, than on ſuch as are high up, is no proof of the aſcent of dew; for the ſame thing is obſerved of rain. A body placed low down receives more rain than one placed in an elevated ſituation; and yet the rain certainly deſcends from the atmoſphere. The reaſon why the dew appears firſt on the lower parts of bodies may be, that, in the evening, the lower part of the atmoſphere is firſt cooled, and conſequently moſt diſpoſed to part with its vapour. It is alſo certain, that part of the water contained in the air may be condenſed at any time on the ſides of a glaſs, by means of cold, ſo as to run down its ſides in ſmall drops like dew. It ſeems, therefore, that this ſubject is not ſufficiently determined by ſuch experiments as have yet been made; nor indeed does it appear eaſy to make ſuch experiments, as ſhall be perfectly deciſive on the matter.

But however this may be determined, it is certain that ſeveral ſubſtances, expoſed to the ſame dew, receive and charge themſelves with it in a very dif-

ferent manner; ſome more, others leſs, and ſome not at all. The drops ſeem to make a ſort of choice of what bodies they ſhall fix themſelves to: glaſs and cryſtals are thoſe to which they adhere in the moſt ready manner, and in the largeſt quantity: but metals of all kinds never receive them at all, nor do the drops ever adhere to them. The reaſon of this is, probably, becauſe metals promote evaporation more than glaſs does. Thus, if a piece of metal and a piece of glaſs are both made equally moiſt, the former will be found to dry in much leſs time than the latter. Hence it would ſeem, that there is between metals and water ſome kind of repulſion: and this may be ſufficient to keep off the very ſmall quantity that falls in dew; for whatever tends to make water evaporate, after it is actually in contact with any ſubſtance, tends alſo to keep the water from ever coming into contact with it.

Of the dew of plants, it has been obſerved, that it is probably only the moiſture that continually exhales through the orifices of their veſſels, and not a vapour collected by their leaves; this dew being exhaled by each plant, according to the peculiar ſtructure of its veſſels, and the ſituation of their orifices. Indeed, it is certain, that plants, which have been ſhut up in veſſels, and covered by glaſſes, have collected a greater quantity of dew, than thoſe that ſtood in the open air; and further, the drops are gathered in thoſe parts where the orifices of the veſſels are manifeſtly open, and not all over the leaves, nor in the upper or lower leaves only (which would be the caſe if they roſe from ambient vapour) but in all the leaves without diſtinction. The oil, or honey-dew, which is ſometimes exhaled in ſummer by trees and herbs, and which has been found to ſettle on the oak, aſh, &c. is of this kind.

Mr. Thomas Melvill, a very ingenious writer in the Eſſays, Phyſical and Literary, by the Edinburgh

Society, publiſhed ſome obſervations On the ſilver-like appearance of drops of water on the leaves of colewort. "It is common (ſays he) to admire the volubility and luſtre of drops of rain that lie on the leaves of colewort, and ſome other vegetables; but no philoſopher, as far as I know, has put himſelf to the trouble of explaining this curious phenomenon. Upon inſpecting them narrowly, I find, that the luſtre of the drop ariſes from a copious reflection of light from the flattened part of its ſurface contiguous to the plant: I obſerve further, that when the drop rolls along a part which has been wetted, it immediately loſes all its luſtre; the green plant being then ſeen clearly through it: whereas, in the other caſe, it is hardly to be diſcerned.

"From theſe two obſervations laid together, we may obſerve, that the drop does not really touch the plant when it has the mercurial appearance, but hangs in the air at ſome diſtance from it, by the force of a repulſive power; for there could not be any copious reflection of white light from its under ſurface, unleſs there were a real interval between it and the ſurface of the plant.

"If that ſurface were perfectly ſmooth, the under ſurface of the drop would be ſo likewiſe; and would therefore ſhow an image of the illuminating body by reflection, like a piece of poliſhed ſilver: but as it is conſiderably rough and unequal, the under ſurface becomes rough likewiſe; and ſo by reflecting the light copiouſly in different directions, aſſumes the reſplendent white colour of unpoliſhed ſilver.

"After it is proved by optical argument, that the drop is really not in contact with the plant that ſupports it, we may eaſily conceive whence its wonderful volubility ariſes, and why it leaves no track of moiſture where it reſts".

Mr. Melvill's explanation will enable us to account for that common phenomenon, the ſuſpenſion

of the drops of dew on the very ſummits of the blades of graſs, &c. and their aſſuming that pearly, or reſplendent white colour, which he obſerved in the drops on the leaves of colewort. This ingenious explanation, at the ſame time, ſhows the extenſive utility of optical principles, in leading to the knowledge of things which would be otherwiſe inacceſſible.

The limits of this paper will not allow me to enlarge on the great benefit of dews in the refreſhment of the earth, and the nouriſhment of plants.—"How ſenſibly (ſays a pious author) has this dew refreſhed the vegetable kingdom! The fervent heat of yeſterday's ſun, had almoſt parched the face, and exhauſted the ſweets of nature. But what a ſovereign reſtorative are theſe cooling diſtillations of the night! How they gladden and invigorate the languiſhing herbs! Sprinkled with theſe reviving drops, their verdure deepens, their bloom is new-fluſhed; their fragrance, faint or intermitted, becomes potent and copious".

In hot-countries, and in places where it rains but ſeldom, the dew of the night ſupplies, in ſome meaſure, the want of rain. In the ſacred ſcriptures, therefore, it is repreſented as a great bleſſing: "Bleſſed of the Lord (ſays Moſes, ſpeaking of Joſeph) be his land for the precious things of heaven, *for the dew*", &c. And the want of it is repreſented as a curſe: "Ye mountains of Gilboa (ſaid David) *let there be no dew*"! The favour of the Divine Being is compared to the dew: "I will be (ſays the Lord, by Hoſea) *as the dew* unto Iſrael: he ſhall grow as the lily, and caſt forth his roots as Lebanon". Heavenly doctrine, or the word of God, is likewiſe compared to dew: "My doctrine (ſays Moſes) ſhall drop as the rain, *my ſpeech ſhall diſtil as the dew*, as the ſmall rain upon the tender herb, and as the ſhowers on the graſs": that is, my doctrine ſhall have the ſame effect upon your hearts, as dew

has upon the earth: it ſhall render them ſoft, pliable, and fruitful.—But the admirable alluſions to dew, in holy writ, are too numerous to be quoted.

In a word, theſe "tranſparent beauties of the morn" not only furniſh us with poetic images and philoſophic knowledge, but with very powerful motives alſo for a life of piety, benevolence, and virtue. Their great utility to the vegetable kingdom, in particular, ſhould lead us to the unceaſing adoration of that gracious Being, who created nothing, which has exiſtence, merely for an object of idle ſpeculation. When we conſider, moreover, how ſilently and inſenſibly "the light-footed dews" fulfil the gracious purpoſes of our common Benefactor; inceſſantly diſpenſing nutriment to vegetable life, and refreſhment to animated being; how perſuaſively ſhould this inſtruct the rich and opulent, to let their ſecret bounty, unoſtentatious as the dew of heaven, deſcend continually to revive the drooping hearts of modeſt and unaſſuming worth. For what are the high and mighty of the earth, without that bliſs-diffuſing ſpirit of humanity, whoſe exertions, while they tend every day to dignify its noble poſſeſſor, prepare and mature him for immortality? What, I repeat it, are illuſtrious titles and unbounded affluence, without this divine ſpirit, but the momentary radiance of the ſame morning dews, which glitter awhile, and then vaniſh away for ever?

XXIV. ON THE FOOD OF PLANTS.

Each tree, each plant, from all its branching roots,
Amid the glebe ſmall hollow fibres ſhoots;
Which drink with thirſty mouths the vital juice,
And to the limbs and leaves their food diffuſe:
Peculiar pores peculiar juice receive,
To this deny, to that admittance give.

BLACKMORE.

IN treating, in a former paper[a], on the influence of the air on vegetation, I was led to take notice of the *pabulum*, or food of plants, as a ſubject of future diſcuſſion. This is a ſubject, indeed, which has been productive of conſiderable diſpute. What is generally underſtood by the term itſelf, is ſuch matter, of whatever kind, as being added and united to the firſt ſtamina of plants, at their ſowing, or to their roots, and thence to their trunks and other parts afterward, gives them their increaſe, or, in other words, is itſelf the matter of that increaſe. The great art of the huſbandman is the giving this food to plants, in the beſt manner, and to the greateſt advantage. But, before he can expect to arrive at any true knowledge in this article, it is neceſſary that he ſhould know what this food or matter of nouriſhment is. There are five things generally allowed to contribute to the growth and increaſe of plants; namely, nitre, water, air, fire, and earth. But it has been much diſputed which of all theſe it is that increaſes, or is properly the food of the plant. Much has been ſaid of the acid ſpirit reſiding in the air; but as this is ſharp enough to corrode iron bars, it is too ſharp to be fit for nouriſhing tender plants. Nitre is ſaid to nouriſh them; but its true office is

[a] No. XV.

not actually nouriſhing, but preparing other things to nouriſh them. Nitre applied to the root of a plant will kill it; but, at a diſtance, it ſo attenuates, cuts, and divides the viſcous matter found in the earth, that after this they are fit to nouriſh plants, although they were not ſo before. Water has been thought by lord Bacon, and others, to be the only food of plants; but a famous experiment of Van Helmont, uſually brought to prove this, is nothing; for the water contains earth, and, therefore, is never given to a plant as water alone.

Air, on account of its elaſticity, is neceſſary to the increaſe of plants; but it does not follow, that it is the matter of that increaſe, although Bradley and others have taken great pains to prove that it is ſo. The experiments of Dr. Prieſtley, indeed, render it a natural concluſion, as mentioned in my paper above referred to, that phlogiſton is the principal food of plants, upon which their nouriſhment and increaſe very much depend. As to fire, we are very well aſſured, indeed, that no plant can live without heat; but, although different degrees of heat are neceſſary to different plants, yet none can live in actual fire; nor has fire been ever thought the food of plants, except by Mr. Lawrence, and ſome of the metaphyſicians. Others maintain, that earth alone is the true food and matter of increaſe in plants. Every plant, ſay the advocates for this opinion, is *earth*; and the growth and increaſe of that plant is only the addition of more earth to it, in the ſame form. They add, that nitre, and other ſalts, as thoſe of dung, &c. prepare, attenuate, and divide the earth, deſtined for the increaſe of vegetables: that water and air move it, by conveying, and fermenting it in the juices; but that earth itſelf is ſtill the food. When the additional earth is once aſſimilated to the plant, it becomes, they aſſert, a part of it, and remains for ever with it; but let water, air,

and heat be taken away, and the plant remains a plant ſtill, although a dead one. They add further, that the exceſs of the other things is a proof, that they are not the proper food of the plant, by deſtroying, inſtead of nouriſhing it: for too much nitre, or other ſalts, corrodes and kills the plant; too much water drowns it; too much air dries the roots of it; too much heat burns it; but too much earth a plant can never have, unleſs entirely buried under it, ſo as to exclude the neceſſary action of the reſt of the aſſiſtant articles.

But how ingenious ſoever theſe arguments may be, more modern experiments and obſervations have led the way to another theory with reſpect to the food of plants, which ſeems to be leſs exceptionable than either of the theories I have ſtated. The ſentiments of the illuſtrious Dr. Hales I have already mentioned in my former paper; in which I likewiſe intimated, what I ſhall now proceed to explain more particularly, the principle to which Dr. Hunter has had recourſe. This gentleman, ſo juſtly celebrated, both as an anatomiſt and a natural philoſopher, was induced by a number of experiments to conclude, that all vegetables receive their principal nouriſhment from oily particles incorporated with water, by means of an alkaline ſalt, or abſorbent earth. Till oil is made miſcible, it is unable to enter the radical veſſels of vegetables; and, on that account, Providence has bountifully ſupplied all natural ſoils with chalky or other abſorbent particles; and thoſe ſoils which have been aſſiſted by art are full of materials for that purpoſe; ſuch as lime, marl, ſoap-aſhes, and the volatile alkaline ſalt of putrid dunghills. Natural ſoils receive their oily particles from the air or atmoſphere, which, during the ſummer months, is full of putrid exhalations from the ſteam of dunghills, the perſpiration of animals, and ſmoke; and every ſhower brings down theſe oleaginous particles

for the nouriſhment of plants. All rich ſoils, in a ſtate of nature, contain oil; and, in lands that have been ploughed for ſóme years, it is found in proportion to the quantity of putrid dung that is laid upon them, allowance being made for the crop they have ſuſtained. By attending to the effects of manures of an oily nature, Dr. Hunter apprehends that we muſt be ſatisfied, that oil, however modified, is one of the chief inſtruments of vegetation. Thus rape-duſt, laid on land, is a certain and ſpeedy manure; as it contains the food of plants ready prepared. Soot is alſo an oily manure, but different from the former, becauſe it contains alkaline ſalt, in its own nature calculated as well for opening the ſoil, as for rendering the oily parts miſcible with water. The dung of pigeons, which feed chiefly upon grains and oily ſeeds, is a rich and quick manure. The dung of horſes that are kept in ſtables, and fed upon beans, oats, and hay, which contain much oil, is alſo a ſtrong manure, more eſpecially when it has undergone the putrid ferment, in order to mix and affimilate its oily, watery, and ſaline parts. Swine's dung is of a ſaponaceous and oily nature, and the richeſt, perhaps, of all the oily manures. The dung of ruminant animals, as cows and ſheep, is preferable to that of horſes at graſs, owing to the quantity of animal juices mixed with their food in chewing; and the fatter the animal, the richer is the dung. Human ordure, which is full of oil and a volatile alkaline ſalt, is of itſelf too ſtrong a manure for any land. The dung of carnivorous animals is plentifully ſtored with oil; animals that feed upon ſeeds and grains come next; and after them follow thoſe that ſubſiſt upon graſs only.

The argument, moreover, in favour of oil being the principal food of plants, is confirmed by the obſervation, that all vegetables, whoſe ſeeds are of an oily nature, are found to be remarkable impo-

veriſhers of the ſoil; as hemp, rape, and flax: and the beſt manures for lands worn out by theſe crops are ſuch as have a good deal of oil in their compoſition, provided that they are laid on with chalk, lime, marl, or ſoap-aſhes, ſo as to render the oily particles miſcible with water.

It muſt be further obſerved, that oily particles conſtitute the nouriſhment of plants in their embryo ſtate; and, by a fair inference, we may ſuppoſe, that ſomething of the ſame nature is continued to them as they advance in growth. The oily ſeeds, as rape, hemp, line, and turnip, conſiſt of two lobes, which, when ſpread upon the ſurface, form the ſeminal leaves: in theſe the whole oil of the ſeed is contained. The moiſture of the atmoſphere penetrates the cuticle of the leaves, and mixing with the oil, conſtitutes an emulſion for the nouriſhment of the plant. The oleaginous liquor being conſumed, the ſeminal leaves, having performed their office, decay. The leguminous and farinaceous plants keep their *placenta*, or ſeminal leaves, within the earth; in which ſituation they ſupply the tender germ with oily nutriment, until its roots are grown ſufficiently ſtrong to penetrate the ſoil.

It has been a received opinion, that lime enriches the land upon which it is laid, by ſupplying it with a ſalt fit for the nouriſhment of plants; but by all the experiments that have been made upon lime, it is found to contain no kind of ſalt. Its operation, therefore, ſhould be conſidered in a different light: by the fermentation which it occaſions, the earth is opened and divided; and, by its abſorbent and alkaline quality, it unites the oily and watery parts of the ſoil. It ſeems alſo to have the property of collecting the acid of the air, which it readily forms into a neutral ſalt, of great uſe in vegetation. It is probable, therefore, that lime tends to rob the ſoil of its oily particles, and will, in time, render it

barren, unleſs care be taken to ſupport it with rotten dung, or other manures of an oily nature. Its great excellence, upon a ſandy ſoil, is by mechanically binding the looſe particles, and thereby preventing the liquid parts of the manure from eſcaping out of the reach of the radical fibres of the plants. Upon clay its effect is different; for, by the gentle fermentation it produces, the unſubdued ſoil is opened and divided; the manures laid on readily come into contact with every part of it; and the fibres of the plants have full liberty to ſpread themſelves. Clay, well limed, will fall in water, and ferment with acids; and, in theſe circumſtances, the air, rains, and dews are freely admitted, and the ſoil is unable to retain the nouriſhment which they reſpectively afford. In conſequence of a fermentation raiſed in the ſoil, the fixed air is ſet at liberty, which promotes vegetation in a ſurpriſing manner.

I have already obſerved, in my former paper, that to this univerſal principle of oil, Dr. Hunter adds another, which is the nitrous acid of the air; for, although experiments have not yet confirmed the efficacy of nitre, conſidered as a manure, he regards it as a vivifying principle in the proceſs of vegetation.

In order to conceive how plants receive their nouriſhment, we muſt recur to the analogy that is known to ſubſiſt between plants and animals. Oil and water ſeem to make up the nouriſhment of both. Earth enters very little into the compoſition of either. It is known that animals take in a great many earthy particles at the mouth, but they are ſoon diſcharged by urine and ſtool. Vegetables take in the ſmalleſt portion imaginable of earth; and the reaſon is, that they have no way to diſcharge it. It is highly probable, that the radical fibres of plants take up their nouriſhment from the earth, in the ſame manner that the lacteal veſſels abſorb the nutriment from the in-

teſtines; and as the oily and watery parts of our food are perfectly united into a milky liquor, by means of the ſpittle, pancreatic juice, and bile, before they enter the lacteals, we have all the reaſon imaginable to keep up the analogy, and ſuppoſe that the oleaginous and watery parts of the ſoil are alſo incorporated, previous to their being taken up by the abſorbing veſſels of the plant. To form a perfect judgement of this, we muſt reflect, that every ſoil, in a ſtate of nature, has in itſelf a quantity of abſorbent earth, ſufficient to incorporate its inherent oil and water; but when we load it with fat manures, it becomes eſſentially neceſſary to beſtow upon it, at the ſame time, ſomething to aſſimilate the parts. Lime, ſoap-aſhes, kelp, marl, and all the alkaline ſubſtances, perform that office. In order to render this operation viſible to the ſenſes, diſſolve one drachm of Ruſſian potaſh in four ounces of water; then add one ſpoonful of oil; ſhake the mixture, and it will inſtantly become a uniform maſs of a whitiſh colour, adapted to all the purpoſes of vegetation. This eaſy and familiar experiment is a juſt repreſentation of what happens after the operation of *burn-baking*, and, conſequently, may be conſidered as a confirmation of the hypotheſis advanced. In this proceſs, the ſward being reduced to aſhes, a fixed alkaline ſalt is produced; the moiſture of the atmoſphere ſoon reduces that ſalt into a fluid ſtate, which, mixing with the ſoil, brings about a union of the oily and watery parts, in the manner demonſtrated in the experiment. When the under ſtratum conſiſts of a rich vegetable mould, the effects of burn-baking will be laſting; but when the ſoil happens to be thin and poor, the firſt crop frequently ſuffers before it arrives at maturity. The farmer, therefore, who is at the expence of paring and burning a thin ſoil, ſhould beſtow upon it a portion of rotten dung, or ſhambles manure, before the aſhes

are ſpread, in order to ſupply the deficiency of oily particles: in this way, the crop will be ſupported during its growth, and the land will be preſerved in health and vigour. Vegetables that have a ſucculent leaf, ſuch as vetches, peas, beans, and buckwheat, draw a great part of their nouriſhment from the air, and, on that account, impoveriſh the ſoil leſs than wheat, oats, barley, or rye, the leaves of which are of a firmer texture. Rape and hemp are oil-bearing plants, and, conſequently, impoveriſhers of the ſoil; but the former leſs ſo than the latter, on account of the greater ſucculency of its leaf. The leaves of all kinds of grain are ſucculent for a time, during which period the plants take little from the earth; but as ſoon as the ear begins to be formed, they loſe their ſoftneſs, and diminiſh in their attractive power. The radical fibres are then more vigorouſly employed in extracting the oily particles of the earth, for the nouriſhment of the ſeed. Dr. Hales obſerves, that the leaves of plants ſerve, not only as excretory ducts, to ſeparate and carry off the redundant watery fluid, which, by being long detained in the plants, would turn tumid and prejudicial to them; but likewiſe to imbibe the dew and rain, which contain ſalt, ſulphur, &c. and to be of the ſame uſe to plants that the lungs are to animals. He adds, however, that as plants have not a dilating and contracting thorax, their inſpirations and expirations will not be ſo frequent as thoſe of animals, but depend entirely on the alternate changes from hot to cold for inſpiration, and *vice verſâ* for expiration. But the greater part of their nouriſhment is derived from their roots [a]. Theſe, therefore, are found to bear a conſiderable proportion to the body of the plant above ground; the ſuperficies of the former being above four tenths of that of the latter.

[a] See No. XXVIII, Reflections on Vegetation.

Hence appears the neceſſity of cutting off many branches from a tranſplanted tree; becauſe, in digging it up, a great part of the roots is cut off.

The facts which I have ſtated above, with regard to the influence of putrid air, ariſing from dunghills, &c. on the nouriſhment and increaſe of plants, were publiſhed by Dr. Hunter, in his Georgical Eſſays in 1769 and 1770; and they were afterward aſcertained in the moſt ſatisfactory manner, by a variety of ſubſequent experiments by Dr. Prieſtley; which led that great philoſopher to the diſcovery of the grand reſtorative of vitiated air, of which, in my paper before referred to, I have given a particular account.

XXV. ON FLOWERS.

It Ver, et Venus, et Veneris prænuntius ante
Pennatus graditur Zephyrus veſtigia propter:
Flora quibus mater præſpargens ante viai
Cuncta coloribus egregiis et odoribus opplet.

LUCRETIUS.

Propitious Spring comes forth in bright array,
With Venus, goddeſs of the vernal day:
Her mild precurſor, Zephyr, wafts the breeze,
With balmy wings, o'er all the budding trees:
Maternal Flora, with benignant hand,
Her flowers profuſely ſcatters o'er the land:
Theſe deck the vallies with unnumber'd hues,
And far around their fragrant ſweets diffuſe.

TO whatever part of the creation the Contemplative Philoſopher may direct his view, he will ever find ſomething productive of pleaſure and inſtruction. Nature exhibits an infinity of objects, which, in

beautiful ſucceſſion, at once excite and gratify our natural ardour for variety. Not only each ſeaſon of the year, but each part of the day, is productive of pleaſures peculiar to itſelf. While the ſun enlightens our horizon, with what unſpeakable beauties does the landſcape glow! How ſweet the glittering dews, the woodland hymns, and brightening verdure of the morn! How delightful the meandring ſtreams, the ruminating herds, and all the flowery beauties of the meads, beheld from ſome ſhady receſs, in the radiant height of noon! What pleaſure in the ſocial, or the ſolitary walk, when the evening ſun deſcends with mitigated ray, and the weſtern ſky is arrayed in ſuch inimitable magnificence of tints! And when the ſhades of night prevail, the milder glories of a moonlight ſcene, with all the ſtarry heavens, ſhed their peculiar influence, and, with the ſenſations of pleaſure, excite the grateful effuſions of wonder and adoration. But theſe are delights for which the gay advocates of licentiouſneſs and diſſipation can have no taſte. They are reſerved, as the ſweeteſt charm of life, for thoſe ſuperior minds that are fond to improve and perfect the habits of virtue, by the conſtant purſuit and acquiſition of intellectual and moral excellence.

Theſe grateful ſhare the gifts of Nature's hand;
  And in the varied ſcenes that round them ſhine,
(The fair, the rich, the awful, and the grand)
  Admire th' amazing workmanſhip divine.

Blows not a flow'ret in th' enamelled vale,
  Shines not a pebble where the riv'let ſtrays,
Sports not an inſect in the ſpicy gale,
  But claims their wonder and excites their praiſe.

For them ev'n vernal Nature looks more gay,
  For them more lively hues the fields adorn;
To them more fair the faireſt ſmile of day,
  To them more ſweet the ſweeteſt breath of morn.

They feel the bliſs that Hope and Faith ſupply;
They paſs ſerene th' appointed hours that bring
The day that wafts them to the realms on high,
The day that centers in eternal ſpring. SCOTT.

The great progenitor of the human race, when firſt conſcious of exiſtence, beheld in all around him the moſt exquiſite aſſemblage of rural beauty. The very name of *Eden*, the delicious paradiſe in which he was placed by the beneficent Creator, ſignifies *pleaſure*; and the idea of pleaſure is inſeparable from that of a garden, in which man ſtill ſeeks the happineſs he has loſt, and in which, perhaps, a good man may find the neareſt reſemblance to it that this world can afford. Hence it has been very juſtly obſerved, that the love of woods, of fields and flowers, of rivers and fountains, ſeems to be a paſſion implanted in our natures the moſt early of any, even before the fair ſex had a being.

Flowers, the ſole luxury which Nature knew,
In Eden's pure and guiltleſs garden grew—
Gay without toil, and lovely without art,
They ſprung to cheer the ſenſe, and glad the heart.
BARBAULD.

I have ever conſidered flowers as the pride and glory of the creation, and the moſt beautiful diſplay of Omnipotent Power in the vegetable kingdom. With the poets too, as the lovely attendants of Spring, they are inexhauſtible ſources of decorations. Not only their favourite ſcenes, but the incidents which they are moſt fond to embelliſh, are enriched with flowers. Thus Virgil makes the ſwain invite Galatea to the ſpot, where Spring ſtrows the river-bank with flowers [a]. Homer, to adorn the bed of Jupiter, makes the Earth pour from her boſom unbidden herbs, and voluntary flowers [b]. Milton, in

a Ecl. ix. b Iliad, b. xiv.

a fine imitation of that paſſage, employs the iris, jeſſamine, and roſe, the violet, hyacinth, and crocus, to beautify the bliſsful bower of Eve [a]. When our firſt parents take their evening repaſt, they recline on the ſoft downy bank damaſked with flowers [b]. When Adam awakes Eve in the morning, it is with a voice mild as when Zephyrus breathes on Flora [c]. And when he invites her to walk forth in the fields, it is to mark how the tender plants ſpring, how Nature paints her colours, and how the bee ſits on the bloom, extracting liquid ſweets [d]. Shakſpeare, in a charming ſimilitude, compares an exquiſite ſtrain of muſic, with its dying fall, to the ſweet South, that breathes upon a bank of violets, ſtealing and giving odour [e]. And, to mention no more, Thomſon, in his noble hymn at the concluſion of the Seaſons, invites the flowery race to join in the general chorus of praiſe to the great Creator:

Soft roll your incenſe, herbs, and fruits and flowers,
In mingled clouds to Him, whoſe ſun exalts,
Whoſe breath perfumes you, and whoſe pencil paints.

I ſhall wave, at preſent, a ſcientific inquiry into the ſtructure, parts, and properties of flowers, in order to introduce ſome reflections on their order of ſucceſſion, and infinite variety. The attentive obſerver will perceive, that every plant upon earth appears in its appointed order. The God of Seaſons, the God of Beauty and Excellence, hath exactly determined the time when *this* flower ſhall unfold its leaves, *that* ſpread its glowing beauties to the ſun, and a *third* hang down its drooping head, and, withered, "reſign its ſunny robes". Long before the trees venture to unfold their leaves, and while Winter yet ventures to maintain his dreary reign, the

a Par. Loſt, b. iv. b Ibid. c Par. Loſt, b. v. d Ibid.
e Twelfth Night, act 1.

ſnowdrop diſplays its milk-white flowerets to the eye:

Firſt leader of the flowery race aſpires,
And foremoſt catches the ſun's genial fires,
Mid froſts and ſnows triumphant dares appear,
Mingles the ſeaſons, and leads on the year.

TICKELL.

Next appears the crocus, too timid yet to reſiſt the impetuoſity of the winds. With this comes the fragrant violet, the expreſſive emblem of that retiring goodneſs, which, with unoſtentatious hand, contributes ſilently to the happineſs of all around. The polyanthus, too, with countleſs colours, and the auricula, ineſtimable for the exquiſite richneſs of its powdered tints, demand the ſkilful culture of the floriſt. Theſe, with many others which grow in foreign countries, upon the mountains, may be called, without impropriety, the vanguard of the flowery hoſt.

Theſe beauteous children of Nature do not appear all at once, but in the moſt enchanting regularity of ſucceſſion. Each month diſplays the beauties peculiar to itſelf. Soon ſucceeds the tulip, the tranſient glory of the garden; the anemone, incircled at the bottom with a ſpreading robe, and rounded, at the top, into a beautiful dome; and the ranunculus, which diſplays all the magnificence of foliage, and charms the eye with ſuch a brilliant aſſemblage of colours. Nor lingers behind the roſe, the favourite flower of poets, which glows with its own vivid tints, and diffuſes around its aromatic ſweets; while the carnation, as if centering in itſelf the perfection of every flower, attracts the wanderer, by that luſtre and variety of hues, and that fragrancy of ſcent, which entitle it to a kind of preeminence over the moſt beautiful of the painted tribes. But not to proceed with the later flowers of the year, I will

conclude my obſervations on this head with Thomſon's picturesque recapitulation:

At once array'd
In all the colours of the flushing year,
By Nature's swift and secret-working hand,
The garden glows, and fills the liberal air
With laviſh fragrance.

* * * * *

Along theſe blushing borders, bright with dew,
And in yon mingled wilderneſs of flowers,
Fair-handed Spring unboſoms every grace;
Throws out the ſnowdrop, and the crocus firſt;
The daiſy, primroſe, violet darkly blue,
And polyanthus of unnumber'd dies;
The yellow wall-flower, ſtain'd with iron-brown;
And laviſh ſtock that ſcents the garden round;
From the ſoft wing of vernal breezes ſhed,
Anemonies; auriculas, enriched
With ſhining meal o'er all their velvet leaves;
And full ranunculus of glowing red.
Then comes the tulip race, where Beauty plays
Her idle freaks: from family diffuſed
To family, as flies the father-duſt,
The varied colours run; and, while they *break*
On the charm'd eye, th' exulting floriſt marks,
With ſecret pride, the wonders of his hand.
No gradual bloom is wanting; from the bud,
Firſt-born of Spring, to Summer's muſky tribes:
Nor hyacinth, of pureſt virgin white,
Low bent, and blushing inward; nor jonquils,
Oft potent fragrance; nor Narciſſus fair,
As o'er the fabled fountain hanging ſtill;
Nor broad carnations, nor gay-ſpotted pinks;
Nor ſhower'd from every buſh, the damaſk-roſe.
Infinite varieties, delicacies, ſmells,
With hues on hues expreſſion cannot paint,
The breath of Nature, and her endleſs bloom.

What an inexhauſtible ſource of grateful admiration does this regular ſucceſſion of flowers preſent! What manifeſt diſplays of Divine Wiſdom and ever

active Goodneſs! Were all the flowers of the different ſeaſons to bloom together in one gay aſſemblage, we ſhould ſometimes be overpowered with profuſion, and at other times lament a total privation. Scarce ſhould we be able to diſcern one half of their innumerable beauties, when the eye, with unſpeakable regret, would witneſs their decay. But while its proper time and place is allotted to every kind of flower, this delightful ſucceſſion enables us to contemplate them with greater convenience and exactneſs. We can often repeat the pleaſing examination, enjoy all their beauties at our leiſure, and form a more intimate acquaintance with them. This wiſe arrangement of Providence affords us another ineſtimable advantage. We not only view the various kinds of flowers, as they flouriſh, in the moſt beautiful perfection, but we become leſs ſenſible on this account of their tranſient duration. The early flowers flouriſh awhile and wither; but a variety of new kinds is conſtantly ſpringing up, to prolong the beauty of the garden, and, as it were, to perpetuate our pleaſure.

The infinite variety of flowers is not leſs a ſubject of admiration than their regular ſucceſſion, and equally evinces conſummate wiſdom and deſign. Had there been an exact uniformity in the ſtructure, form, and colour, the fragrancy and other properties of flowers, that uniformity would have become fatiguing, and we ſhould ſoon have languiſhed for the charms of novelty. Or if the ſummer were to be productive of no other flowers than what adorn the ſpring, we ſhould not only become weary of contemplating them, but neglect to beſtow upon them the neceſſary care of cultivation. The Divine Goodneſs is indeed apparent, in having diverſified the productions of the vegetable kingdom in ſuch a delightful manner, as to add to their perfections the charms of a variety ever pleaſing and ever new.

This diverſity is not diſcernible only in the different families of flowers, but it is to be ſeen, moreover, in the individuals. While the carnation is different from the tulip, and the tulip from the auricula; each carnation, each tulip, and each auricula has its peculiar character, with its particular beauties and varieties. In each there is ſomething original. In a bed of tulips or carnations, there is ſcarce a flower in which ſome difference may not be obſerved in its ſtructure, ſize, or aſſemblage of colours; nor can any two flowers be found in which the ſhape and ſhades are exactly ſimilar.

Some flowers rear their lofty heads, as if in proud preeminence over others, that riſe to a moderate height, or keep their humble ſtation near the ground. Some glow with the moſt gaudy colours, while others charm the eye with their elegant ſimplicity. With what maſterly ſkill are the varying tints diſpoſed; magnificently bold in ſome; in others delicately faint; laid on in *theſe* with a kind of negligence, and adjuſted in *thoſe* by the niceſt touches of art! Some perfume the air with the moſt exquiſite odours; while others are content to delight the eye, without gratifying the ſenſe of ſmell. In fine, we behold that ſucceſſive beauty, that pleaſing variety, and that endearing novelty in flowers, in compariſon of which all the works of art muſt appear inſipid and diſguſting.

Flowers, it may be ſuppoſed, have not only furniſhed the poets, as I have before obſerved, with inexhauſtible deſcription, but the philoſophers in every age with a variety of moral ſentiments. But reflections of this kind will lead me too far: I ſhall therefore conclude this paper with ſome beautiful lines, which I have ſelected, in particular, for the inſtruction of my fair readers.

Ye lovely Fair, while flowery chaplets bind
Your youthful brows, and o'er the verdant paths

Of gently-gliding life, ye graceful ſweep,
Array'd in purple pride; as on your breaſt
The diamond ſhines, and in your floating train
The ruby glows, and emeralds around
Beſet the flying robe; while dazzling thus
In orient pomp, forgive if yet the Muſe
In moralizing ſtrains eſſays to draw
The evening veil o'er all the glittering ſhow.
Vain is their blaze, which, like the noontide day,
Dazzles the eye: ſo flaunt the gaudy flowers
In vernal glory, wide diffuſing round
Their odoriferous ſweets, and ſhoot profuſe
Their bloſſoms forth, and flouriſh in their May,
In Nature's livery clad; but when the ſun
Beams in his pride, they droop their bluſhing heads,
Their bloſſoms wither, and their varied tints
Fade with his ſultry rays. Behold, ye Fair,
Your gay deluſions; read in Nature's book
Their tranſitory life, how quickly fleets
The dream of pleaſure——
So beauty fades, ſo fleets its ſhowy life,
As droops the lily, clad in all its pride
Of rich array.—— ANON.

XXVI. THE ANATOMY OF FLOWERS.

Go, mark the matchleſs workings of the Power,
That ſhuts within the ſeed the future flower;
Bids theſe in elegance of form excel,
In colour theſe, and thoſe delight the ſmell;
Sends Nature forth, the daughter of the ſkies,
To dance on earth, and charm all human eyes.
COWPER.

IN my former paper I conſidered the ſubject of flowers in a poetical, philoſophical, and moral view; deducing ſuch reflections from their order of

ſucceſſion, their exquiſite beauty, and infinite variety, as might impreſs the thinking mind with the love and veneration of that Great Being, who, in the moſt minute parts of his creation, diſplays ſuch wiſdom and benevolence. But if ſuch wiſdom and benevolence appear in the exterior decoration of flowers, what ſuperior ſubjects of admiration will the Contemplative Philoſopher diſcover, when he examines their conſtituent parts, or what may properly be called, the Anatomy of Flowers. In every part he will find a wonderful harmony and concurrence of deſign, ſubſervient to every end for which the whole was created, and inceſſantly productive of it.

Before I proceed in this examination of the conſtituent parts of flowers, it will be neceſſary to obſerve, that the modern ſyſtem of botany, invented by ſir Charles Linné, is called the Sexual Syſtem; it being founded on a diſcovery, that there is in vegetables, as well as in animals, a diſtinction of ſexes. This doctrine was very imperfectly known to the ancients. The generality of flowers have been diſcovered to be hermaphrodite, that is, to contain within them, the characters of both ſexes: in one claſs of vegetables the ſexes are divided, and allotted to different flowers on the ſame plant; in another claſs, the male flowers grow all upon one plant, and the female upon another. This laſt circumſtance did not eſcape the obſervation of the ancients. From the palm-tree, the fruit of which was held in great eſtimation, they could not but learn, that as the male flowers were upon one tree, and the female upon another, the flowers of the male were neceſſary to ripen the fruit of the female. That their practice was conformable to this idea, is evident from the account which Herodotus gives, in his firſt book, of the country about Babylon. The palm-trees there were univerſally an object of cultivation;

and it was common for the inhabitants to aſſiſt the operations of Nature, by gathering the flowers of the male trees, and conveying them to the female. Thus they ſecured the ripening of the fruit, which otherwiſe, from unfavorable ſeaſons, or the want of a proper intermixture of the trees of each ſex, might have been precarious, or greatly deficient at leaſt in the expected quantity.

It is rather ſurpriſing that this diſcovery did not lead the ancients, acute and penetrating as they were, to diſcover the entire proceſs of Nature in the propagation of the various ſpecies of vegetables; and yet it does not appear that they ever went beyond this obvious remark upon the palm-tree, and ſome ſimilar ideas concerning the fig. Indeed, from what they ſaw of theſe plants, they had conceived an opinion, that all other plants were likewiſe male and female; but this opinion was groundleſs, the far greater part of plants having hermaphrodite flowers. It is evident, therefore, that what they diſcovered of the palm and fig was only a juſt conjecture, but not founded on any knowledge of the anatomy of flowers, either in thoſe trees, or in any others.

The doctrine of the ſexes of vegetables continued in this obſcure ſtate almoſt to the end of the 17th century; ſo many ages having paſſed away before the moderns were more enlightened in this reſpect than the ancients. The honour of having firſt ſuggeſted the true ſexual diſtinction in plants is due to ſir Thomas Millington, the learned Savilian profeſſor; from whoſe hints Dr. Grew was led to his obſervations on this ſubject, in his Anatomy of Plants, publiſhed in 1682. After this, Moreland and Bradley, among the Engliſh; Camerarius and Blair among the Scots; and Geoffroy, Vaillant, and Juſſieu, among the French; purſued their reſearches and experiments with ſuch ſucceſs, as to aſcertain this diſcovery beyond the poſſibility of doubt. And, finally,

ſir Charles Linné, the celebrated Swede, founded on this diſcovery that ſyſtem of botany which is now univerſally received.

Agreeably to this ſyſtem I ſhall now proceed to treat of the conſtituent parts of a perfect flower. Of theſe, which are ſeven in number, the firſt is called the calyx, empalement, or cup. It is the termination of the outer bark of the plant, which, after accompanying the trunk or ſtem through all its branches, breaks out with the flower. It has received different appellations, according to the circumſtances with which it is attended. In the roſe, and ſome other flowers, the calyx conſiſts of thoſe outſide green leaves which incloſe the flower in the bud. In others, it conſiſts of one funnel-like cup, as in polyanthuſes and auriculas. In corn or graſs, it is called the huſk. In the willow or filbert, it forms the catkins, or that aſſemblage of imperfect flowers which hangs from the tree in the manner of a rope, or cat's tail. In all theſe varieties the uſe of the empalement is to defend the young tender flower while yet in its blooming ſtate. But flowers that are very robuſt, as the tulip, crown-imperial, and lily, have no empalement.

The ſecond object in the ſtructure of flowers is the corolla, or foliation, which is the termination of the inner bark continued to, and accompanying, the fructification, in this new form of painted leaves. The leaves of which the corolla conſiſts, are called petals, to diſtinguiſh them from the green leaves of the plant with which they might otherwiſe be confounded. Linné defines the petal to be a corolaceous covering to the flower; meaning that it incloſes and protects it in the manner of a corolla or wreath. In theſe petals, which conſtitute the moſt conſpicuous part of the flower, not only the moſt exquiſite beauty and luxuriant colours are obſervable, but alſo the very curious manner in which they are folded in

the empalement, before they are expanded. The uſe of the corolla is the ſame as that of the calyx, ſerving as an inner work of defence for the parts it incloſes, as the calyx, which is uſually of a ſtronger texture, does for an outer one.

Among the varieties obſervable in the corolla, there is one part, called the nectarium, which has been but recently diſtinguiſhed, having been confounded by former botaniſts with the petals. Linné defines it to be the part which bears the honey, and belonging to the flower only. This part affords a wonderful variety in the manner of its appearance. In ſome plants it is very large, as in the daffodil and columbine; in the former of which the cup, and in the latter the horns, are nectaria. In others it is ſcarce diſcoverable even with g'aſſes. In ſome plants it is united with, and makes part of, the petals; in others, it is detached from them. Its ſhape and ſituation are alſo as various. Its uſe is not known, unleſs the ſuppoſition of its ſecreting the honey may be depended upon.

The ſtamina form the third conſtituent part in flowers. Linné defines them as an entrail of the plant, deſigned for the preparation of the pollen, otherwiſe called the farina fœcundans, or fertilizing duſt. Each ſingle ſtamen conſiſts of two parts; firſt, the filament, or thread, vulgarly called the chive, which ſerves to elevate the anthera, apex, or ſummit, and at the ſame time connects it with the flower; ſecondly, the anthera itſelf, which contains within it the fertilizing duſt, and, when come to maturity, diſcharges the ſame. The pollen is a fine duſt, ſecreted within the anthera, and deſtined for the impregnation of the germen or bud. It is, indeed, the immediate organ of fertilization in the ſeed of plants, and where this is wanting to fertilize the ſeed, ſuch ſeed will never produce a plant. A remarkable experiment to prove this occurs in the 47th volume of the

Philoſophical Tranſactions. There was a great palm-tree in the garden of the royal accademy at Berlin, which flowered and bore fruit for thirty years, but the fruit never ripened, and when planted, it did not vegetate. The palm-tree, as before obſerved, is one of thoſe in which the male and female parts of generation are upon different plants. There being no male plant in this garden, the flowers of the female were never impregnated by the farina of the male. At Leipſic, twenty German miles from Berlin, was a male plant of this kind, from which, in April 1749, a branch of male flowers was procured, and ſuſpended over the female ones. This experiment was ſo ſucceſsful, that the palm-tree produced more than a hundred perfectly ripe fruit, from which they had eleven young palms. On repeating the experiment, the next year, the palm-tree produced above 2000 ripe fruit.—This experiment fully eſtabliſhes the fact, atteſted by the ancients, concerning the palm-tree, which ſome, perhaps, may have regarded as fabulous; and as the fructification in other vegetables, although it may differ in particular circumſtances, has yet, in general, an evident conformity with that of the palm-tree, in reſpect to the parts ſuppoſed to be the organs of generation, which are diſcoverable either on the ſame, or on a ſeparate flower, in all but one particular claſs, called Cryptogamia, in which they are too minute for obſervation; ſo, from this ſingle experiment, an argument may be deduced by analogy, for the confirmation of the whole ſexual hypotheſis.

If we take one of theſe antheræ, or apices, from a ſunflower, and view it through a microſcope, we ſhall obſerve a great number of ſmall yellow balls on each ſide of the apex, or ſummit, which is open on both ſides. The ſurface of the apex will be obſerved almoſt covered with them. Thoſe upon the concave

will appear extremely pretty, being ſpiculated all around; they will likewiſe be found to be perfectly globular, and of a fine yellow tranſparency. Theſe balls contain a very ſubtile, pellucid, oily fluid, or ſpirit, which is eaſily obſerved when ſome of them are bruiſed upon the glaſs.—In a word, as the ſtamina, which thus includes the antheræ and the pollen, is the male part of the flower, wherever the ſtamina is wanting that flower is female.

The fourth part of a flower is the piſtil, which is a very eſſential one, being the female part. Linné defines it to be an entrail of the plant, deſigned for the reception of the pollen. It conſiſts of three parts; 1. the germen, or bud, which is the rudiment of the fruit accompanying the flower, but not yet arrived at maturity; 2. the ſtyle, which is the part that ſerves to elevate the ſtigma from the germen; and, 3. the ſtigma, which is the ſummit of the piſtil, and covered with a moiſture for the breaking of the pollen.

I have already obſerved, that the pollen was deſtined for the impregnation of the germen, which is thus performed: The antheræ, which, at the firſt opening of the flower, are whole, burſt open ſoon after, and diſcharge the pollen; which diſperſing itſelf about the flower, part of it lodges on the ſurface of the ſtigma, where it is detained by the moiſture with which that part is covered; and each grain or atom of the pollen burſting and diſſolving in this liquor, as it has been obſerved to do by the microſcope, is ſuppoſed to diſcharge ſomething which impregnates the germen below. What the ſubſtance is, that is ſo diſcharged, and whether it actually paſſes through the ſtyle into the germen, ſeems yet undetermined, it being difficult to obſerve ſuch minute parts; but whatever be the operation by which Nature produces the effect in queſtion, the cauſe, as far as it has been here explained, is ſcarce diſpu-

table; and accordingly we ſee, that after this impregnation, when the parts of the flower that have done their office are fallen away, the germen ſwells to a fruit big with ſeed, by which the ſpecies is propagated. And thus, as wherever the ſtamina is wanting the flower is female; in like manner, wherever the piſtil is wanting, the flower is male: ſuch as have both, are called hermaphrodite, and ſuch as have neither, neuter.

The fifth part of a flower is the pericarpium, or ſeed veſſel, which is the germen grown to maturity. Linné defines it to be an entrail of the plant big with ſeed, which it diſcharges when ripe. They have ſeveral ſcientific names, correſponding to their reſpective natures, whether they be pods, legumes, nuts, apples, berries, &c.

The ſeed, which is the ſixth part of a flower, is, according to the definition of Linné, the deciduous part of a vegetable, the rudiment of a new one, quickened for vegetation by the ſprinkling of the pollen. It is the ultimate produce, yet incipient principle, of vegetative nature. It is the natural offspring of the flower, and that for whoſe production all its parts ſeem intended; ſo that when this is once well formed, the ſeveral parts of the flower dwindle and diſappear.

The ſeventh and laſt part, is the receptacle, which is the baſe, that connects the other ſix parts of fructification.

From this account of the anatomy of flowers, it appears how very ſuperficial is the judgement of thoſe who imagine the ſtudy and cultivation of them beneath their notice. "I have been often ſurpriſed (ſays a fine writer) to find thoſe who poſſeſſed a very acute ſuſceptibility of artificial or literary grace, and were powerfully affected by the beauties of a poem, a piece of ſculpture, or a painting, not at all more ſenſible of the charms of a tree, or a flowret, than a

common or inelegant ſpectator. They have dwelt with rapture on a fine deſcription of the vale of Tempe; they have entered into all the delight which a Shakſpeare or a Milton meant to communicate, in their enchanting pictures of flowery and ſylvan ſcenes, and yet can walk through a wood, or tread on a bank of violets and primroſes, without appearing to be affected with any peculiar pleaſure. This is certainly the effect of a ſuperficial judgement; for there is no truth of which philoſophers have been longer convinced, than that the realities of Nature infinitely exceed the moſt perfect productions of imitating art".—What then ſhould be our ſenſations, when to the diſplay of unſpeakable beauty in all, are added the great deſigns of unceaſing and unbounded benevolence! But, not to carry this diſcuſſion to too great a length, I will conclude with the following animated lines from Thomſon:

Who can paint
Like Nature? Can Imagination boaſt
Amid its gay creation, hues like hers?
Or can it mix them with that matchleſs ſkill,
And loſe them in each other, as appears
In every bud that blows? If Fancy then,
Unequal fails beneath the pleaſing taſk,
Ah! what ſhall language do? Ah! where find words,
Ting'd with ſo many colours; and whoſe power,
To life approaching, may perfume my lays
With that fine oil, thoſe aromatic gales,
That inexhauſtive flow continual round.

XXVII. REFLECTIONS ON THE MODERN ART OF GARDENING.

The love of Nature, and the ſcenes ſhe draws,
Is Nature's dictate. COWPER.

Hail to the Art, that teaches Wealth and Pride
How to poſſeſs their wiſh, the World's applauſe,
Unmixt with blame! that bids Magnificence
Abate its meteor glare, and learn to ſhine
Benevolently mild———————
——————— Gothic Pomp
Frowns and retires, his proud beheſts are ſcorn'd:
Now Taſte, inſpir'd by Truth, exalts her voice,
And ſhe is heard. MASON.

WHATEVER delight we find in contemplating the works of Art, whether magnificently great, or elegantly minute, nothing is more certain, than that Nature, in all her varieties of aſpect, is ſtill more irreſiſtibly enchanting. The vulgar and uninformed, indeed, in the proſpect of a fine country, look no further than to the different ſcenes of cultivation; for they have ſeldom any other object of attraction than mere utility. The obſervations with which they are content, are, perhaps, that the barley is fine, and the clover rich: obſervations which a mere quadruped would make with equal ſagacity, were it endued with the gift of ſpeech. But the ideas of the Contemplative Philoſopher are more extenſive and ſublime. To culture, indeed, he gives the praiſe which it unqueſtionably demands; while he extends his enraptured eye to the ſpontaneous beauties of Nature, or to the happy improvements of them which aſſiſting Art effects; and which, while they charm, not ſo much by diſtant proſpect as by the beauties of diverſified landſcape, afford the pureſt ſources of elegant and virtuous pleaſure.

The pleaſures which ariſe from the obſervation of Nature are ſuch, indeed, as muſt be highly agreeable to every taſte undepraved by culpable indulgence. Rural ſcenes, in particular, are delightful to the mind of man. The verdant plains, the flowery meads, the ſhady woods, and winding ſtreams; the ruminating herds, the playful lambs, the warbling birds, and even the rooks with harſh and diſcordant ſound, are all capable of exciting the ſweeteſt and moſt agreeable emotions. And yet the greater part of mankind are hurried on ſo rapidly in the purſuits of life, and ſo agitated by contending paſſions, that they have neither leiſure to obſerve, nor a taſte to admire objects ſo uncongenial to their education, their habits, and their wiſhes. And with many, not only the palaces, but even the moſt gloomy habitations of the metropolis, where riches may be acquired, have far more attractive charms than the moſt enchanting ſcenery of the country.

Strange! there ſhould be found
Who ſelf-impriſon'd in their proud ſaloons,
Renounce the odours of the open field
For the unſcented fictions of the loom;
Who, ſatisfied with only pencil'd ſcenes,
Prefer to the performance of a God
Th' inferior wonders of an artiſt's hand.
Lovely indeed the mimic works of Art,
But Nature's works far lovelier. I admire,
None more admires the painter's magic ſkill,
Who ſhows me that which I ſhall never ſee,
Conveys a diſtant country into mine,
And throws Italian light on Engliſh walls.
But imitative ſtrokes can do no more
Than pleaſe the eye, ſweet Nature every ſenſe.
The air ſalubrious of her lofty hills,
The cheering fragrance of her dewy vales,
And muſic of her woods—no works of man
Can rival theſe: theſe all beſpeak a power
Peculiar, and excluſively her own. COWPER.

From theſe general obſervations on the natural beauties of the country, it is an eaſy ſtep to thoſe decorations of Art with which the man of true taſte can enliven and improve even the charming ſcenes of Nature; and which, ſo far from excluding cultivation for mere decoration, or the uſeful for the agreeable, often happily aſſociate them both. Thus in Thomſon's fine deſcription of the retirement of ſir Induſtry, in his Caſtle of Indolence, he has united culture and ornament, or, in other words, has given us a happy ſketch of "The modern Art of Gardening":

Nor from his deep retirement baniſh'd was
Th' amuſing care of rural induſtry.
Still, as with grateful change the ſeaſons paſs,
New ſcenes ariſe, new landſcapes ſtrike the eye,
And all th' enliven'd country beautify:
Gay plains extend where marſhes ſlept before;
O'er recent meads th' exulting ſtreamlets fly;
Dark frowning heaths grow bright with Ceres' ſtore,
And woods imbrown the ſteep, or wave along the ſhore.

As nearer to the farm you made approach,
He poliſh'd Nature with a finer hand:
Yet on her beauties durſt not Art encroach.
'Tis Art's alone thoſe beauties to expand.
In graceful dance immingled, o'er the land,
Pan, Paleas, Flora, and Pomona play'd:
Here, too, briſk gales the rude wild common fand[a]
A happy place; where free, and unafraid,
Amid the flowery brakes each coyer creature ſtray'd.

The poets, in every age, have been enraptured with the beauties of a garden, how various ſoever their ideas of its conſtituent parts. The Elyſian Fields, thoſe ſweet regions of poetry, are adorned with all that Fancy can imagine to be delightful. Homer deſcribes the garden of Alcinons in the richeſt poetry; and Ovid wanders with rapture through

[a] Uſed by Spenſer for *found*: it is ſtill retained in Scotland.

his Theſſalian Tempe. Lucan is repreſented by Juvenal as repoſing in his garden. Horace prayed for a villa where there was a garden, a rivulet, and a grove; and Virgil languiſhed for the enjoyment of rivers and woods, and the cool vallies of Mount Hæmus. The latter, too, as appears from his Georgics, was not only highly captivated with rural ſcenes, but a great cultivator of them. In the fourth book of the Georgics he ſeems to lament, that the limits of his ſubject would not permit him to ſing of gardens. He gives us pleaſure, however, in a rapid and delightful ſketch of horticulture, and the affecting epiſode of a venerable old man, happy in cultivating and adorning a few barren and forſaken acres. What the Roman poet regretted he could not do, was performed in the 17th century by father Rapin, who wrote a poem on gardens, in the language, and ſometimes in the ſtyle of Virgil. But his poem, which is didactic, treats only of the mechanical part of the Art of Gardening. He has entirely forgotten the moſt eſſential part, that which ſeeks, in our ſenſations and ſentiments, for the ſource of thoſe pleaſures which the beauties of Nature inſpire, when improved and perfected by Art. In a word, his gardens are the gardens of the architect; but not the delicious haunts of the philoſopher, the painter, and the poet.

Some of the moſt intereſting and delightful paſſages in Milton are thoſe in which he repreſents the happy pair employed in cultivating their bliſsful abode. Thomſon, in his charming poem of the Seaſons, has not been content with the moſt luxuriant deſcriptions of rural ſcenes, but has deduced from them the moſt ſublime moral and religious themes. Shenſtone transferred his fine poetical paintings to his few paternal acres, and made them flouriſh there in the moſt beautiful reality. And ſince his time, the abbé de Lille in France, and our

countryman, Maſon, have publiſhed regular didactic poems on the modern Art of Gardening, in which they have enlivened the dryneſs of preceptive poetry by all the captivating powers

Of "muſic, image, ſentiment, and thought,
Never to die"!

Mr. Maſon begins his admirable poem with an invocation to Simplicity, as the inſeparable attendant on genuine beauty and unaffected grace. He likewiſe invokes the two ſiſter arts of Poetry and Painting to promote a kindred art; an art in which the attributes of both are engaged. Hence he conſiders the garden as a picture, the unadorned and naked ſoil as the painter's canvaſs, and all the means of decoration as the pencil and colours with which he is to work. The ſame idea is likewiſe beautifully expreſſed by the abbé de Lille:

Un jardin, à mes yeux, eſt un vaſte tableau.
Soyez peintre. Les champs, leurs nuances ſans nombre,
Les jets de la lumière, et les maſſes de l'ombre,
Les heures, les ſaiſons, variant tour-à-tour
Le cercle de l'année et le cercle du jour,
Et des prés émaillés les riches broderies,
Et des rians côteaux les vertes draperies,
Les arbres, les rochers, et les eaux, et les fleurs.
Ce ſont là vos pinceaux, vos toiles, vos coleurs.

To me the garden a vaſt picture ſeems:
Be painter then. The ample fields around;
Their varying ſhades, unnumber'd, that diſplay
The vivid rays of light, or maſs of gloom;
The hours, and ſeaſons, and revolving ſtill
The circle of the year and circle of the day;
The meads in variegated beauty bright;
The ever-cheering verdure of the hills;
The ſtreams; the rocks; the rivers; and the flow'rs;
Thy pencils theſe, thy canvas, and thy tints.

Agreeably to this idea, the Modern Art of Gar-

dening has been juſtly ſtyled an imitation of the Deity in the moſt beautiful of his viſible works. The great elements of this ſpecies of beauty ſeem to be wood, water, and uneven ground; to which may be added a fourth, that is to ſay, lawn. It is the happy mixture of theſe four that produces every ſcene of natural beauty, as it is a more myſterious mixture of other elements, perhaps as ſimple and as few, that is productive of a world or a univerſe.

The painters ſeem to have felt the force of theſe elements, and to have tranſplanted them into their landſcapes with ſuch felicity, that they have rather emulated than imitated Nature. Claude Lorraine, the Pouſſins, Salvator Roſa, and a few more in the 17th century, may be called ſuperior artiſts in this exquiſite taſte. Yet with all their ſuperiority to their contemporaries in landſcape-painting, lord Kames obſerves, that it requires more genius to paint in the gardening way. "In forming a landſcape upon canvaſs (ſays this elegant and philoſophic writer) no more is required but to adjuſt the figures to each other; an artiſt who would form a garden in Kent's manner, has an additional taſk; which is, to adjuſt the figures to the ſeveral varieties of the field".

But while the genuine beauties of Nature were diſplayed on the canvaſs, our gardens, till the 18th century, exhibited ſcenes, which, in every reſpect, were taſteleſs and inſipid. The artiſts of thoſe times imagined, that the further they wandered from Nature, the nearer they approached to the ſublime. Unfortunately, where they travelled no ſublime was to be found; and the further they went the further they left it behind. Perfection in no ſcience whatever has been the work of a day. Many prejudices were to be removed; many gradual aſcents to be made from bad to good, and from good to better, before the delicious amenities of a Claude or

a Pouſſin could be rivalled in a Stourhead, a Hagley, or a Stow; or the tremendous beauties of a Salvator Roſa could be equalled in the ſcenes of a Piercefield or a Mount Edgecombe.

O how unlike the ſcene my fancy forms,
Did Folly, heretofore, with Wealth conſpire
To plant that formal, dull, disjointed ſcene,
Which once was called a garden. Britain ſtill
Bears on her breaſt full many a hideous wound
Given by the cruel pair, when, borrowing aid
From geometric ſkill, they vainly ſtrove
By line, by plummet, and unfeeling ſheers,
To form with verdure what the builder form'd
With ſtone. Egregious madneſs; yet purſu'd
With pains unwearied, with expenſe unſumm'd,
And ſcience doating. Hence the ſideling walls
Of ſhaven yew; the holly's prickly arms
Trimm'd into high arcades; the tonſile box
Wove, in moſaic mode of many a curl,
Around the figur'd carpet of the lawn.
Hence too deformities of harder cure:
The terrace mound uplifted; the long line
Deep delv'd of flat canal; and all that Toil,
Miſled by taſteleſs Faſhion, could achieve
To mar fair Nature's lineaments divine. MASON.

Mr. Horace Walpole, in an ingenious eſſay on modern Gardening, has quoted ſeveral paſſages from Milton, full half a century before the appearance of Kent, the great reformer of Gardening, to ſhow that our divine bard had the juſteſt and moſt perfect ideas of this beautiful art. But I will not repeat the obſervations of this lively writer, which are too copious to be quoted. The reader who would trace the gradual proſpect of a more enlightened taſte in Gardening, and who would form a juſt idea of the reformation which Kent effected, will read Mr. Walpole's remarks with particular ſatisfaction. I ſhall be content to obſerve, that the Art of Gardening,

which may be called the luxury of agriculture, appears to me one of the moſt becoming, and I had almoſt ſaid, the moſt virtuous amuſements of the wealthy. As culture, it recalls them to the innocence of rural occupations: as decoration, it favours, without danger, that taſte for expenſe which is ſo naturally attendant on great fortunes. And far ſuperior are ſuch pleaſures to the ordinary purſuits of the great, in ſenates and in courts.

Couldſt thou reſign the park and play content,
For the fair banks of Severn or of Trent;
There might'ſt thou find ſome elegant retreat,
Some hireling ſenator's deſerted ſeat;
And ſtretch thy proſpects o'er the ſmiling land,
For leſs than rent the dungeons of the Strand;
There prune thy walks, ſupport thy drooping flow'rs,
Direct thy rivulets, and twine thy bow'rs;
And while thy beds a cheap repaſt afford,
Deſpiſe the dainties of a venal lord:
There every buſh with Nature's muſic rings,
There ev'ry breeze bears health upon its wings;
On all thy hours ſecurity ſhall ſmile,
And bleſs thy evening walk and morning toil.

JOHNSON.

XXVIII. REFLECTIONS ON VEGETATION.

Your contemplation further yet purſue;
The wondrous world of vegetables view!
See various trees their various fruits produce,
Some for delightful taſte, and ſome for uſe.
See ſprouting plants enrich the plain and wood,
For phyſic ſome, and ſome deſign'd for food.
See fragrant flowers, with different colours dy'd,
On ſmiling meads unfold their gaudy pride.

BLACKMORE.

IN Spring, when Nature has again beautified the earth with the brighteſt colours, and univerſal life and cheerfulneſs pervade the whole creation, my inquiries are naturally directed to the great principle of vegetation, by which ſuch a wonderful transformation has been effected. But the ſubject is too copious and too extenſive to be treated of with ſyſtematic accuracy: I ſhall be content, therefore, to point out ſome of its moſt prominent and pleaſing features to the contemplation and admiration of my readers.

The definition of a plant is the firſt object of inquiry. Boerhaave defines a plant to be an organical body, compoſed of veſſels and juices; to which body belongs a root, or a part by which it adheres to ſome other body, and particularly the earth, from which it derives the matter of its life and growth. It is diſtinguiſhed from a foſſil by its being organized, and conſiſting of veſſels and juices; and from an animal, by its adhering to another body, and deriving its nouriſhment from it.

That plants are organized bodies, and endued with life, is evident from a variety of conſiderations, and, particularly, from a degree of ſpontaneous mo-

tion obſervable in them. Thus, herbs, in greenhouſes or ſtoves, incline toward the light: when ſhut up, if they find a hole in the wall, ſhutters, or frames, they will endeavour to penetrate. Several plants, in the daytime, turn their flowers toward the ſun: moſt plants, in a ſerene ſky, expand their flowers; but, before rain, ſhut them up, or contract them at the approach of night. The flowers of many plants hang down in the night, as if the plants were aſleep, leſt rain, or the moiſt air ſhould injure the fertilizing duſt. The trefoils, and others, ſhut up, or double their leaves before ſtorms or tempeſts, but unfold them in a clear ſky. The tamarind-tree is ſaid by Alpinus and Acoſta to infold within its leaves the flowers or fruit every night, in order to guard them from cold or rain. Some of the ſenſitive plants, and the wood-ſorrel, with pinnated leaves, upon being touched, roll up their leaves, and turn downward or ſhrink, and, after a little time, expand them again, as if they had both life and ſenſation. And it further appears, that motion is no leſs neceſſary to the vigour of plants, than exerciſe is to the health and ſtrength of animals. Thus plants, in ſtoves and greenhouſes, although they have ſufficient heat and nouriſhment, are ſlender and weak, loſe the colour of their leaves, and ſeem to languiſh for want of motion. And trees ſurrounded by high walls or buildings, and confined within narrow bounds, are ſlender, and grow tall, but not ſtrong.—From the obſervations, moreover, of ſome celebrated naturaliſts, a great ſimilarity appears between the mechaniſm of plants and that of animals; the parts of the former bear ſome analogy to thoſe of the latter; and the vegetable and animal economy appear to be formed on the ſame model.

The ſtructure of plants is next to be conſidered. The roots, ſtalk, branches, leaves, flowers, and fruit, compriſe all that is moſt remarkable in their

external parts.—The roots, by means of their different kinds of hinges, tuberoſities, and ramifications, keep the plant fixed to the earth; while their pores imbibe an exceeding fine ſlime, which the water liquifies, and carries with it. From the root ſprings the ſtalk, to which the plant partly owes its ſtrength and beauty. Being ſometimes ſhaped like a pipe, the ſtalk is fortified by knots ſkilfully diſpoſed. As it is ſometimes too weak to ſupport itſelf, it twiſts round a ſolid prop, faſtening by means of the little hands with which it is furniſhed. In ſome it appears a ſtrong pillar, rearing its proud head aloft in the air, and braving all the fury of ſtorms and tempeſts.

The branches ſhoot forth like ſo many arms, from the trunk and ſtalk, on which they are diſtributed with great regularity. They are divided and ſubdivided into many ſmall boughs; the ſubdiviſions obſerving the ſame order as the principal diviſions.

The leaves, the charming ornaments of plants, are diſpoſed round the ſtalk and branches with the ſame ſymmetry. Some are ſimple, others compound, or formed of various foliage. One ſort is plain, another indented. Some of them are very thin; others hard, ſoft, plump, ſmooth, rough, hairy, &c.

The flowers, whoſe beautiful enamel is one of the principal glories of Nature, are not leſs diverſified than the leaves. Some have only a ſingle leaf or petal; others ſeveral. Here it appears like a large veſſel gracefully opening: there it forms ſome groteſque figure, in imitation of a muzzle, headpiece, or cowl. Here it is a butterfly, a ſtar, a crown, a radiant ſun. Some are ſcattered on the plant without any art: others compoſe noſegays, globes, tufts of feathers, garlands, pyramids, &c.—The greater part of them are furniſhed with a calyx; ſometimes plain and ſimple; ſometimes conſiſting of ſeveral pieces, or properly cut. From the centre of

the flower proceeds one or more little pillars, called piſtils, which are either ſmooth or channelled, rounded at top, or terminating in a point. Theſe commonly encircle other ſmaller pillars called ſtamina, which carry on the upper part of them a ſort of ſmall bladders, full of an exceeding fine powder, called the pollen, or fertilizing duſt; every grain of which, viewed through a microſcope, appears of a very regular figure, but varied according to its ſpecies. In ſome they are ſmall ſmooth globes; in others they are thickly ſet with prickles, like the covering of a cheſtnut; and ſometimes they reſemble ſmall priſms, or ſome other regular body.—The flowers are ſucceeded by an infinite profuſion of fruit and ſeed [a].

All fruits and ſeeds have this in common, that they incloſe under one or more coverings the germ of the future plants. Some have only ſuch coverings as immediately infold the germ, whoſe outſide is of the ſtrongeſt contexture; and, among theſe, there are ſome that are provided with wings, tufts, plumes of feathers, &c. by means of which they are conveyed in the air or water, ſo as to be tranſported and ſown in different parts. Others are better clothed: being lodged in ſheaths or pods, incloſed in a kind of box, having one or more partitions. A third ſort, under a delicious fruit, which is rendered ſtill more agreeable by its beautiful colour, contain a ſtone and kernel. Others are incloſed in ſhells, which are either armed with prickles, abound with a bitter juice, or are adorned with a very fine down or hair.—The outſide of fruits and ſeeds, moreover, do not afford leſs variety than that of the leaves and flowers, there being ſcarce a figure whatever, of which they do not exhibit an exact repreſentation.

Such are the exterior parts of plants: the internal

[a] See No. xxvi, for an account of the Anatomy of Flowers, and the ſexual ſyſtem of plants.

are compoſed of four orders of veſſels, namely, the ligneous fibres, the utriculi or little bags, the proper vaſes, and the tracheæ or air veſſels.

The ligneous fibres are very ſmall channels depoſited according to the length of the plant, and conſiſting of little tubes placed near each other. Sometimes theſe veſſels are parallel, and at others are ſeparated, leaving between them intervals, or oblong ſpaces, which are filled by the utriculi, a kind of membraneous bladders, horizontally diſpoſed, and communicating with each other. The proper veſſels are a kind of ligneous fibres, that differ from the reſt principally by their juice, which is of a deeper colour, or thicker. In the middle of theſe, or round a great number of ligneous fibres, are ſome veſſels, which are not ſo narrow, compoſed of a ſilvery elaſtic blade, formed ſpirewiſe, like a ſpring. Theſe are arteries, and ſeldom contain any thing but air.

Theſe four orders of veſſels, which are diſperſed through all the parts of the vegetable, in proportion to the nature and function of each, compoſe, at leaſt in trees and ſhrubs, three principal and concentric beds, the bark, the wood, and the pith.—The bark or rind, which is the outer covering, is ſmooth, even, and ſhining in ſome, and rough, channelled, and hairy in others: it is formed of the wideſt fibres, that are the leaſt preſſed together, and which admit within them the moſt air.—The wood, which is placed under the rind, has, on the contrary, narrower and more contracted tubes. Its utricles are leſs repleniſhed or dilated; and this only has arteries.—The pith, which is ſituate in the heart of the plant, is little more than a collection of utricles, which are greater and more capacious than thoſe of the bark and wood.

From the ſtructure of plants we proceed to their nutrition, by their roots and leaves.—The ſaline,

unctuous, and ſubtile ſlime which the water ſeparates from the coarſe earth, and keeps in a diſſolved ſtate, is the principal nutriment of plants. The different ſpecies of manure only contribute to the fertilizing of land, in proportion as they introduce into it a greater quantity of a ſpongy powder or active ſalt [a].

After having been admitted into the body of the root by the extremity of the fibres, the nutritious juice riſes into the ligneous fibres from the trunk or ſtalk, and paſſes into the utricles that adhere to them. It is there prepared and digeſted. It afterward enters into the proper veſſels, under the form of a coloured fluid more or leſs thick, which we may conjecture to be with reſpect to the plant, what the chyle or blood is to the animal. Being filtered by finer or more winding tubes, it is at laſt conveyed to all the parts, to which it unites, and increaſes their bulk.

The quantity of nutriment which a plant derives from the earth is in proportion to the number and ſize of its leaves; the ſmaller and fewer in number the leaves are, the leſs it draws.

The nutrition of vegetables is likewiſe effected immediately by their leaves. They not only ſerve for raiſing the ſap, preparing it, and diſcharging its ſuperfluity, but they are a kind of roots that pump from the air the juices they tranſmit to the neighbouring parts. The dew, which ariſes from the ground, is the principal foundation of this aërial nouriſhment. The leaves preſent to it their inferior ſurface, which is always furniſhed with an infinite number of ſmall pipes that are always ready to abſorb it. And that the leaves may receive no prejudice in the exerciſe of this function, they are diſperſed with ſuch art on the ſtalk and branches, that thoſe which immediately precede, do not cover ſuch

[a] See No. XXIV, on the Food of Plants,

as ſucceed them. Sometimes they are placed alternately on two oppoſite and parallel lines. Sometimes they are diſtributed by pairs, that croſs each other at right angles. Sometimes they are ranged on the angles of polygons circumſcribed on the branches, and ſo diſpoſed, that the angles of the inferior polygon correſpond with the ſides of the ſuperior. And ſometimes the leaves aſcend the whole length of the ſtalk and branches, in one or more parallel ſpiral lines.

By a mechaniſm, which is doubtleſs very ſimple, the root of the plant forces itſelf into the earth, the branches ſhoot out on each ſide, the leaves expoſe their ſuperior ſurface to the open air, and their inferior ſurface to the earth, or the inner part of the plant. If a ſeed be ſown the contrary way, the radicle and little ſtalk will each bend backward; the former, in order to penetrate into the earth, and the latter to gain the air. If a young ſtalk be kept inclined, its extremity, notwithſtanding, will grow upright. Bend the branches of all ſorts of plants; cauſe the inferior ſurfaces of their leaves to turn toward the ſky; you will ſoon perceive that all theſe leaves will reſume their former poſition.

Many great naturaliſts have ſuppoſed a circulation of the ſap in plants; but Dr. Hales has demonſtrated, that the ſap does not circulate, but that it *aſcends* and *deſcends*.—In order to underſtand the motion of the ſap, according to his principles, it is to be conſidered, that during the heat of a ſummer's day, all plants perſpire freely from the pores of their leaves and bark. At that time, their juices are highly rarefied. The diameters of the tracheæ, or air-veſſels, are enlarged, ſo as to preſs upon and ſtraiten the veſſels that carry the ſap; in conſequence of which, their juices, not being able to eſcape by the roots, are preſſed upward where there is the leaſt reſiſtance, and perſpire off the excrementitious

parts by the leaves and branches, in the form of vapour. When the ſolar heat declines, the tracheæ are contracted, the ſap veſſels are enlarged, and the ſap ſinks down in the manner of the ſpirits of a thermometer. In conſequence of this change, the capillary veſſels of the leaves and top branches become empty. Being ſurrounded with the humid vapours of the evening, they fill themſelves, from the known laws of attraction, and ſend down the new acquired juices to be mixed with thoſe that are more elaborated. As ſoon as the ſun has altered the temperature of the air, the tracheæ become again diſtended, and the ſap-veſſels are ſtraitened. The ſame cauſe always produces the ſame effect; and this alternate aſcent and deſcent through the ſame ſyſtem of veſſels, continues as long as the plant ſurvives. The irregular motion of the ſtem and branches is another cauſe that contributes to the aſcent of the ſap. Whenever theſe parts are agitated by the air, they are made to aſſume a variety of angles, whereby the ſap-veſſels are ſuddenly ſtraitened. The contained juices, conſequently receive reiterated impulſes, ſimilar to what happens to the blood of animals from the contraction of the heart. Theſe obſervations convey a general idea of the motion of the ſap, which varies according to the temperature of the weather, which is ſeldom the ſame in any ſucceeding moment; and, therefore, the ſap muſt ſometimes move more quick, and ſometimes ſlow: it may riſe and fall many times in the day, puſhed forward by ſudden heats, and falling by ſudden cold.' Thus the juices are blended, and the ſecretions forwarded.

XXIX. THE PROCESS OF NATURE IN THE VEGETATION OF PLANTS.

Nor only through the lenient air this change,
Delicious, breathes; the penetrative ſun,
His force deep-darting to the dark retreat
Of vegetation, ſets the ſtreaming power
At large, to wander o'er the vernant earth,
In various hues. THOMSON.

Hos natura modos primum dedit: his genus omne
Sylvarum fruticumque viret. VIRGIL.

Thus Nature did ordain,
For trees, and ſhrubs, and all the ſylvan reign.
DRYDEN.

THE theory of the aſcent and deſcent of the ſap in plants, with which I concluded my former paper, is beautifully adopted by Thomſon, in a noble apoſtrophe to the God of Seaſons:

Hail, Source of Being! Univerſal Soul
Of heaven and earth! Eſſential Preſence, hail!
To thee I bend the knee; to thee my thoughts,
Continual, climb; who, with a maſter-hand,
Haſt the great whole into perfection touch'd.
By thee the various vegetative tribes,
Wrapt in a filmy net, and clad with leaves,
Draw the live ether, and imbibe the dew:
By thee diſpos'd into congenial ſoils,
Stands each attractive plant, and ſucks, and ſwells
The juicy tide, a twining maſs of tubes:
At thy command the vernal ſun awakes
The torpid ſap, detruded to the root
By wintry winds; that now in fluent dance,
And lively fermentation, mounting, ſpreads
All this innumerous-colour'd ſcene of things.

I ſhall now conſider the very curious and admirable proceſs of nature in the vegetation of plants, which is deſcribed to this effect by the excellent Malphigi and others: The ſeed of the plant, after it has dropped from the pod or huſk, may be conſidered as an impregnated egg, within which the embryo plant is ſecurely lodged. In a few days after it has been committed to the earth, may be obſerved the rudiments of the future plant, every part of which appears to exiſt in miniature. The nutritious juices of the ſoil inſinuate themſelves between the original particles of the plant, and bring about an extenſion of its parts. This is called the growth of the vegetable body; and, with regard to this increaſe by addition and extenſion, there ſeems to be a great analogy between the animal and vegetable kingdoms, on which, however, I ſhall not enlarge.

To illuſtrate the ſubject of vegetation, let us take a view of what happens to a bean, after it has been committed to the earth. In a few days, ſooner or later, according to the temperature of the weather and diſpoſition of the ſoil, the external coverings open at one end, and diſcover to the naked eye part of the placenta or body of the grain. This ſubſtance conſiſts of two lobes, or diviſions, between which the ſeminal plant is ſecurely lodged. Soon after the opening of the membranes, a ſharp-pointed body appears, which is the root. By a kind of principle, which ſeems to bear ſome appearance of inſtinct, it ſeeks a paſſage downward, and fixes itſelf into the ſoil. At this period, the root is a ſmooth and poliſhed body, and has, perhaps, but little power to abſorb any thing from the earth, for the nutriment of the germ or ſprout. The two lobes now begin to ſeparate, and the germ, with its leaves, may be plainly diſcovered. As the germ increaſes in ſize, the two lobes are further ſeparated, and the tender leaves, being cloſely joined, puſh themſelves forward

in the form of a wedge. Theſe leaves take a contrary direction to the root. They ſeek a paſſage upward, which having obtained, they lay aſide their wedge-like form, and ſpread themſelves in a horizontal direction, as being the beſt adapted for receiving the rain and dew. The root, increaſing every hour in ſize and vigour, puſhes itſelf deeper into the earth, from which it now draws ſome nutritive particles. At the ſame time, the leaves of the germ, being of a ſucculent nature, aſſiſt the plant, by attracting from the atmoſphere ſuch particles as the tender veſſels are fit to convey. Theſe particles, however, are of a watery kind, and have not in their own nature a ſufficiency of nutriment for the increaſing plant. Vegetables, as well as animals, during their tender ſtate, require a large ſhare of balmy nouriſhment. As ſoon as an animal is brought into life, the milk of its mother is ſupplied in a liberal ſtream; while the tender germ ſeems to have only the crude and watery juices of the earth for its ſupport. This, however, is not the caſe: for the vegetable lives upon a ſimilar fluid, although differently ſupplied. For its uſe, the farinaceous lobes are melted down into a milky juice, which, as long as it laſts, is conveyed to the tender plant by innumerable ſmall veſſels, which are ſpread through the ſubſtance of the lobes. Theſe veſſels, uniting into one common trunk, enter the body of the germ, and perform the office of an umbilical chord. Without this ſupply of balmy liquor, the plant muſt inevitably have periſhed, its root being then too ſmall to abſorb a ſufficiency of food, and its body too weak to aſſimilate it into nouriſhment.

Turnips, and all the tribe of cabbages, in oppoſition to the leguminous and farinaceous plants, ſpread their ſeminal leaves[a] upon the ſurface: theſe

[a] All ſeeds have two coverings, which anſwer to the *chorion* and *amnion* in anatomy, and two lobes, or diviſions, which perform the

leaves contain all the oil of the ſeed, which, when diluted by the moiſture of the atmoſphere, forms an emulſion of the moſt nouriſhing quality; and, on account of its ſweetneſs, the ſeminal leaves are greedily devoured by the fly. A grain of wheat, as ſoon as the germ has made its appearance, ſhows the milky liquor to the naked eye; but the umbilical chord, with its ramifications, can be diſcovered only by the aſſiſtance of the niceſt glaſſes. As the plant increaſes in ſize, the balmy juice diminiſhes, till, at laſt, it is quite exhauſted. The umbilical chord then dries up, and the external covering of the grain appears connected with the root in the form of a ſhrivelled bag. In the proceſs of vegetation, there is no mortality: from the moment that the ſeed is lodged in its parent earth, the vegetative ſoul begins its operations, and, in the whole ſucceſſive gradation of them, illuſtrates the wiſdom, the power, and the bounty of Providence. It is worthy of obſervation, moreover, that farinaceous vegetables and oviparous animals are nouriſhed in their tender ſtate nearly in the ſame manner. The embryo plant is ſupported by the farina melted down into a milky liquor, and conveyed into its body by means of an umbilical chord, at a time when the radicle was unable to ſupply a ſufficiency of nutriment. An oviparous animal, from the time that it is brought into

office of the *placenta*. Theſe lobes conſtitute the body of the ſeed; and, in the farinaceous kinds, they are the flour of the grain. Innumerable ſmall veſſels run through the ſubſtance of the lobes, which, uniting as they approach the ſeminal plant, form a ſmall chord to be inſerted into the body of the grain. Through this the nutriment ſupplied by the placenta or lobes is conveyed for the preſervation and increaſe of the embryo plant. Here it may be obſerved, that the lobes of farinaceous grains are fixed in the earth; they are, therefore, improperly termed *ſeminal leaves*, being rather the *placenta* or *cotyledons* of the plant. On the contrary, vegetables that have an oily ſeed, as rape, hemp, and turnip, carry their lobes upward, and ſpread them upon the ſurface in the form of broad leaves. Theſe, though they perform the office of a placenta, are properly ſeminal leaves.

light, ſeems to receive all its nouriſhment from without; but this is in appearance only. The yolk of the egg, remaining entire during incubation, is received into the body of the animal, and, in a manner ſimilar to the milky juice of the vegetable, is ſlowly conveyed into the veſſels of the tender chick; and thus a ſweet nouriſhment is prepared at a time, when neither the induſtry of the animal, nor the attention of its mother, could have procured a ſufficient ſupply.

That the whole plant is contained in the ſeed, is an opinion as old as Empedocles; and it is ſtill the prevailing doctrine among the generality of naturaliſts. Experience, the microſcope, and the modern philoſophy, give great countenance to it: for it is certain, that by the uſe of good microſcopes, we diſcover, in the ſeed, ſeveral of the parts of the future plant, only in miniature; particularly a little root called the *radicle*, and the ſtem called the *plumule*.

In the life of Malphigi, we have a debate between him and ſignor Triumphetti, provoſt of the phyſic garden at Rome, whether the whole plant be actually contained in the ſeed. The affirmative is maintained by Malphigi, with cogent arguments; among which this is one, that in a kidneybean, before ſown, the eye, aſſiſted by the microſcope, eaſily diſcovers leaves, a bud, and even the knots or implantations of the leaves on the ſtem. The ſtem itſelf alſo is very conſpicuous, and plainly conſiſts of woody fibres, and a ſeries of little utricles. And Triumphetti having objected, that by poverty, tranſplantation, &c. ſeveral plants degenerated into others, particularly wheat into tares, and tares again into wheat; in anſwer to this, which is one of the ſtrongeſt objections againſt that opinion, Malphigi replies, that he is not fully ſatisfied as to the truth of the objection; for that both he himſelf, and his friends, having made the experiment, no metamorphoſis of the wheat ſuc-

ceeded; but, granting the metamorphoſis, it is the ſoil, or the air, or the culture, that is in fault. Now, from a morbid and monſtrous condition of Nature, there is no inferring her genuine and permanent ſtate.

On this ſubject of ſeeds, there is one circumſtance, which is too curious and remarkable to be paſſed over; namely, that in all countries, whether agriculture be promoted or neglected by mankind, Nature aſſiſts to ſow and plant, as well as to fertilize the earth. The ſeeds of lofty trees are many of them winged; and, when they are ripe, the autumnal winds blow them off, and ſcatter them at a great diſtance from their mother plants. Others are in pods or huſks, and not capable of being carried by the motion of the air; but Providence has given them as food to birds, who carry them to diſtant places, and, in feeding, ſcatter part of the ſeed in ſoils proper for them to take root in and ſpring up. Even the droughts of the autumn contribute to increaſe and propagate trees and plants; for by cauſing deep chinks in the earth, the ſeeds of trees, and larger plants, that require depth, are lodged at proper depths for their growth, and, at the ſame time, ſecured from ſuch animals as feed upon them. Many of the ſeeds of annual plants are provided with a light down, by which they are enabled, with the help of the wind, to riſe to great heights, and ſpread themſelves very wide to propagate their ſpecies in diſtant lands. The ſun, by its annual viſit to the northern and ſouthern tropics, alternately gives action and reſt to vegetation. The floods, which, in many countries, fall, at certain ſeaſons, from the mountains, cover the plains, and enrich the ſoil by the ſediment of their waters. The froſts of winter, alſo, by expanding the moiſture contained in the earth, looſen and break the clods, ſo as to make them give way to the ſpreading roots of vegetables; and ſwine, moles,

and ſuch other animals, root up and looſen the earth, and fit it to receive the roots of plants.

Then ſpring the living herbs, profuſely wild,
O'er all the deep-green earth, beyond the power
Of botaniſt to number up their tribes:
Whether he ſteals along the lonely dale,
In ſilent ſearch; or through the foreſt rank,
With what the dull incurious weeds account,
Burſt his blind way; or climbs the mountain rock,
Fir'd by the nodding verdure of its brow;
With ſuch a liberal hand has nature flung
Their ſeeds abroad; blown them about in winds;
Innumerous mix'd them with the nurſing mould,
The moiſt'ning current, and prolific rain. THOMSON.

Birds are natural planters of many ſorts of wood and trees: they diſſeminate the kernels upon the earth, which, like nurſeries, bring them forth till they grow up to their natural ſtrength and perfection. Crows have been obſerved, at the latter end of autumn, planting a grove of oaks: they firſt made little holes in the ground with their bills, going about till the hole was deep enough, and then they dropped in the acron, and covered it with earth and moſs. Some think, that Providence has given the crows this inſtinct, ſolely for the propagation of trees: but others are of opinion, that it was given them principally for their own preſervation, by hiding proviſion in time of plenty, in order to ſupply them in a time of ſcarcity; for it is obſerved, in tame pies and daws kept about houſes, that they will hide their meat when they have plenty, and fetch it from their hiding-places when they want it. Such an inſtinct, therefore, in birds, may anſwer a double purpoſe, both their own ſupport in times of need, and the propagation of the trees they plant; for, whenever they hide a great number of nuts or grain in the earth, we cannot ſuppoſe they find them all again, but that as many will remain in the plat of ground

they make uſe of, as can well grow by one another. I ſhall add to this obſervation concerning this natural diſperſion of ſeeds, that Providence has been amazingly bountiful in the wonderful increaſe of ſeed in many vegetables; inſomuch, that with proper culture, the face of the whole earth might be covered, in a very few years, *from the ſeed of a ſingle plant.*

XXX. ON VARIOUS PHENOMENONS IN THE VEGETABLE KINGDOM.

Admiration, feeding at the eye,
And ſtill unſated, dwells upon the theme.

COWPER.

THE vegetable kingdom, conſidered in various points of view, exhibits innumerable phenomenons, which excite great variety of ſentiment and inexhauſtible conjecture.—Among theſe, the curious botaniſt will not fail to obſerve the locomotive faculty which vegetables poſſeſs, the extreme ſenſibility of ſome, and that remarkable phenomenon, in particular, which is called the *ſleep of plants.*

That power of changing place, which is called the locomotive faculty, is not peculiar to animals. Examples of different kinds of motion are to be diſcovered in the vegetable kingdom. When the roots of the tree, for inſtance, meet with a ſtone, or any other obſtruction to their motion, in order to avoid it, they change their former direction. They will turn, moreover, from barren to fertile earth, which indicates ſomething analagous to a ſelection of food; and when confined to a houſe, they will uniformly

bend toward the window, or aperture, through which the rays of light are introduced.

The Mimoſa, or Senſitive Plant, poſſeſſes the faculty of motion in a very eminent degree. On the ſlighteſt touch its leaves ſuddenly contract, and the branch bends toward the earth. The ingenious Dr. Darwin, in his poem called the Botanic Garden, thus deſcribes this delicate plant:

Weak with nice ſenſe, the chaſte Mimoſa ſtands,
From each rude touch withdraws her timid hands;
Oft as light clouds o'erpaſs the ſummer-glade,
Alarm'd ſhe trembles at the moving ſhade;
And feels alive thro' all her tender form,
The whiſper'd murmurs of the gathering ſtorm;
Shuts her ſweet eyelids to approaching night,
And hails with freſhen'd charms the riſing light.
Veil'd, with gay decency and modeſt pride,
Slow to the moſque ſhe moves, an eaſtern bride;
There her ſoft vows unceaſing love record,
Queen of the bright ſeraglio of her lord.
So ſinks or riſes, with the changeful hour,
The liquid ſilver in its glaſſy tower;
So turns the needle to the pole it loves,
With fine librations quivering as it moves.

But the Hedyſarum Gyrans, or Moving Plant, from the Eaſt Indies, where it is called Chundali Borrum, by the natives, exhibits the moſt aſtoniſhing example of vegetable motion. Its leaves are inceſſantly in ſpontaneous movement; ſome riſing and others falling; and others whirling circularly by twiſting their ſtems. Dr. Darwin, who places this plant, according to the Linnean or ſexual ſyſtem of Botany, in the claſs *Diadelphia*, *two brotherhoods*, *ten males*, thus deſcribes the Hedyſarum, in his beautifully fanciful account of the Loves of the Plants:

Fair Chunda ſmiles amid the burning waſte,
Her brow unturban'd, and her zone unbrac'd;

Ten brother-youths with ſlight umbrellas ſhade,
Or fan with buſy hands the panting maid;
Looſe wave her locks diſcloſing as they break,
The riſing boſom and averted cheek;
Claſp'd round her ivory neck with ſtuds of gold
Flows her thin veſt in many a gauzy fold;
O'er her light limbs the dim tranſparence plays,
And the fair form, it ſeems to hide, diſplays.

The motions of the Hedyſarum ceaſe during the night, and when the weather is cold and cloudy. Our wonder is excited by the rapidity and conſtancy of the movements peculiar to this plant. The frequency, however, of ſimilar motions in other plants, may render it probable that the leaves of all vegetables move, or are agitated by the rays of the ſun, although many of theſe movements are too ſlow for our perception.

The American plant called Dionæa Muſcipula, or Venus' Flytrap, affords another inſtance of rapid vegetable motion. Its leaves are jointed, and furniſhed with two rows of ſtrong prickles. Their ſurfaces are covered with a number of minute glands, which ſecrete a ſweet liquor, and allure the approach of flies. When theſe parts are touched by the legs of a fly, the two lobes of the leaf inſtantly riſe up, the rows of prickles lock themſelves faſt together, and ſqueeze the unwary animal to death. If a ſtraw or pin be introduced between the lobes, the ſame motions are excited. Dr. Darwin ſays, that the ſweet viſcous liquor juſt mentioned, is a curious contrivance of Nature, to prevent various inſects from plundering the honey, or devouring the ſeed; and he thus poetically deſcribes the plant and this its remarkable peculiarity:

The fell Silene and her ſiſters fair,
Skill'd in deſtruction, ſpread the viſcous ſnare.
The harlot-band *ten* lofty bravoes ſcreen,
And frowning guard the magic nets unſeen.

Haſte, glittering nations, tenants of the air,
Oh, ſteer from hence your viewleſs courſe afar!
If with ſoft words, ſweet bluſhes, nods, and ſmiles,
The *three* dread ſyrens [a] lure you to their toils,
Limed by their art in vain you point your ſtings,
In vain the efforts of your whirring wings!
Go, ſeek your gilded mates and infant hives,
Nor taſte the honey purchaſed with your lives.

When a ſeed is ſown in a reverſed poſition, the young root turns downward to enter the earth, and the ſtem bends upward to aſcend into the air. Confine a young ſtem to an inclined poſition, and its extremity will ſoon aſſume its former perpendicular direction. Twiſt a branch of any tree in ſuch a manner that the inferior ſurfaces of the leaves are turned toward the ſky, and, in a ſhort time, all theſe leaves will reſume their original poſition. Theſe motions are performed ſooner or later, in proportion to the degree of heat, and the flexibility of the leaves. Many leaves, as thoſe of the mallow, follow the courſe of the ſun. In the morning, their ſuperior ſurfaces are preſented to the eaſt; at noon, they regard the ſouth; and, when the ſun ſets, they are directed to the weſt. During the night, or in rainy weather, theſe leaves are horizontal; and their inferior ſurfaces are turned toward the earth. The helianthus, or ſunflower, alſo, follows the courſe of the ſun:

Great Helianthus guides o'er twilight plains
In great ſolemnity his derviſe-trains;
Marſhal'd in *fives* [b] each gaudy band proceeds,
Each gaudy band a *plumed* [c] lady leads;

[a] Three females and ten males inhabit each flower.

[b] The numerous florets, which conſtitute the diſk of this flower, contain in each five males ſurrounding one female; and the five ſtamens have their anthers connected at top, whence the name of the claſs 'confederate males'.

[c] The ſeeds of many plants of this claſs are furniſhed with a *plume*, by which admirable mechaniſm they are diſſeminated by the winds far

With zealous ſteps he climbs the upland lawn,
And bows in homage to the riſing dawn;
Imbibes with eagle-eye the golden ray,
And watches, as it moves, the orb of day.

What has been denominated the *ſleep of plants*, affords an inſtance of another ſpecies of vegetable motion. The leaves of many plants fold up during the night; but, at the approach of the ſun, they expand with new vigour. The common appearances of moſt vegetables are ſo changed in the night, that it is difficult to recogniſe the different kinds, even by the aſſiſtance of light.

The modes of folding in the leaves, or of ſleeping, are extreemly various. But it is worthy of remark, that they all diſpoſe themſelves ſo as to give the beſt protection to the young ſtems, flowers, buds, or fruit. The leaves of the tamarind-tree contract round the tender fruit, and protect it from the nocturnal cold. The Caſſia or Senna, the Glycine, and many of the papilionaceous plants, contract their leaves in a ſimilar manner. The leaves of the Chickweed, of the Aſclepias, Atriplex, &c. are diſpoſed in oppoſite pairs: during the night, they riſe perpendicularly, and join ſo cloſe at the top, that they conceal the flowers. The leaves of the Sida or Althæa Theophraſti, of the Ayenia, and Œnothera, are placed alternately: though horizontal, or even depending, during the day, at the approach of night they riſe, embrace the ſtem, and protect the tender flowers. The leaves of the So-

from their parent ſtem, and look like a ſhuttlecock, as they fly. Other ſeeds are diſſeminated by animals: of theſe ſome attach themſelves to the hair or feathers by a gluten, as miſſeto; others by hooks, as cleavers, burdock, houndſtongue; and others are ſwallowed for the ſake of the fruit, and voided uninjured, as the hawthorn, juniper, and ſome graſſes: other ſeeds again are diſperſed by means of an elaſtic ſeed-veſſel, as oats, geranium, and impatiens: and the ſeeds of aquatic plants, and of thoſe that grow on the banks of rivers, are carried many miles by the currents into which they fall.

lanum, or Nightſhade, are horizontal during the day; but, in the night, they riſe and cover the flowers. The Egyptian Vetch erects its leaves during the night, in ſuch a manner, that each pair ſeems to be one leaf only. The leaves of the White Lupine, in the ſtate of ſleep, hang down, and protect the young buds from being injured by the nocturnal air.

Theſe and ſimilar motions are not peculiar to the leaves of plants. The flowers have alſo the power of moving. During the night, many of them are incloſed in their calixes. Some flowers, as thoſe of the German Spurge, Geranium Striatum, and common Whitlow-graſs, when aſleep, hang their mouths toward the earth, to prevent the noxious effects of rain or dew.

The cauſe of thoſe movements which conſtitute the ſleep of plants, has been aſcribed to the preſence or abſence of the ſun's rays. In ſome of the examples I have given, the motions produced are evidently excited by heat. But plants kept in a hot-houſe, where an equal degree of heat is preſerved both day and night, fail not to contract their leaves, or to ſleep, in the ſame manner as when they are expoſed to the open air. This fact evinces, that the ſleep of plants is rather owing to a peculiar law, than to a quicker or ſlower motion of their juices.

It would be preſumptuous, perhaps, in the preſent imperfection of human knowledge, to exclude plants from every ſpecies of ſenſation. The degrees of ſenſation decreaſe imperceptibly from man to the ſea-nettle, gall-inſects, and what are called the moſt imperfect animals. Every vegetable, as well as the ſenſitive plant, ſhrinks when wounded. But, in moſt of them, the motion is too ſlow for our perception. When trees grow near a ditch, the roots which proceed in a direction that would neceſſarily bring them into the open air, inſtead of continuing

this noxious progreſs, ſink below the level of the ditch, then ſhoot acroſs, and regain the ſoil on the oppoſite ſide. When a root is uncovered, without expoſing it to much heat, and a whet ſponge is placed near it, but in a different direction from that in which the root is proceeding, in a ſhort time the root turns toward the ſponge. In this manner the direction of roots may be varied at pleaſure. All plants make the ſtrongeſt efforts, by inclining, turning, and even twiſting their ſtems and branches, to eſcape from darkneſs and ſhade, and to procure the influences of the ſun. Place a whet ſponge under the leaves of a tree, they ſoon bend downward, and endeavour to apply their inferior ſurfaces to the ſponge. If a veſſel of water be placed within ſix inches of a growing cucumber, in twenty-four hours the cucumber alters the direction of its branches, bends either to the right or left, and never ſtops till it comes into contact with the water. When a pole is placed at a conſiderable diſtance from an unſupported vine, the branches of which are proceeding in a contrary direction from that of the pole, in a ſhort time, it alters its courſe, and ſtops not till it clings around the pole. But facts, of this kind, however they may excite our wonder, are far from proving that vegetables live, or that they are endowed with ſenſation, which implies a diſtinct perception of pleaſure and pain.

Plants, undoubtedly, make a very near approach to animals; and this ſimilarity, as well as the difficulty of fixing the preciſe boundaries by which theſe two great kingdoms of nature are limited, are direct conſequences of the organization of vegetables. It is owing to their organic ſtructure alone, that plants and animals are capable of affording reciprocal nouriſhment to each other. This organic ſtructure, though greatly diverſified in the different ſpecies of animals and vegetables, evinces that Nature, in the

formation of both, has acted upon the same general plan. "May we not presume, therefore (says an ingenious naturalist [a]) that as plants as well as animals are composed of a regular system of organs, that the vegetable part of the creation is not entirely deprived of every quality which we are apt to think peculiar to animated beings? I mean not to insinuate, that plants can perceive pleasure or pain. But, as many of their motions and affections cannot be explained upon any principle of mechanism, I am inclined to think, that they originate from the power of irritability, which, though it implies not the perception of pleasure and pain, is the principle that regulates all the vital or involuntary motions of animals. To ascertain this point, would require a set of very nice experiments. I shall mention one, which might be performed with tolerable ease. It was formerly remarked, that plants kept in a hothouse, where the degree of heat is uniform, never fail to sleep during the night. This is direct evidence, that heat alone is not the cause of their vigilance. But they are deprived of light. Let, therefore, a strong artificial light, without increasing the heat, be thrown upon them. If, notwithstanding this light, the plants are not roused, but continue to sleep as usual, then it may be presumed that their organs, like those of animals, are not only irritable, but require the reparation of some invigorating influence which they have lost while awake, by the agitations of the air and the sun's rays, by the act of growing, or by some other latent cause.

Of some plants it is remarkable, that they flower only in the night, and of others, that it is then only they emit their fragrance. The Cactus Grandiflorus, or Night-blowing Cereus [b], which is a native of Jamaica and Vera Crux, expands a very exquisitely

a Dr. Smellie, in his Philosophy of Natural History.

b Twenty males, one female.

beautiful corol, and emits a very fragrant odour, for a few hours in the night, and then closes to open no more. The flower is nearly a foot in diameter, the inside of the calyx of a splendid yellow, and the numerous petals of a pure white. It begins to open about seven or eight in the evening, and closes before sunrise.—Of its appearance in its native climes our botanical poet thus sings, in a beautiful apostrophe:

Nymph! not for thee the radiant day returns,
Nymph! not for thee the golden solstice burns,
Refulgent Cerea!—At the dusky hour
She seeks, with pensive step the mountain bower,
Bright as the blush of rising morn, and warms
The dull cold eye of Midnight with her charms.
Then to the skies she lifts her pencil'd brows,
Opes her fair lips, and breathes her virgin vows;
Eyes the white zenith; count the suns, that roll
Their distant fires, and blaze around the pole;
Or marks where Jove directs his glittering car
O'er heaven's blue vault,—Herself a brighter star.
There, as soft Zephyrs sweep with pausing airs
Thy snowy neck, and part thy shadowy hairs,
Sweet Maid of Night! to Cynthia's sober beams
Glows thy warm cheek, thy polish'd bosom gleams.
In crowds around thee gaze th'admiring swains,
And guard in silence the enchanted plains;
Drop the still tear, or breathe th' impassioned sigh,
And drinks inebriate rapture from thine eye.

The Nyctantheus, or Arabian Jasmine, is another flower, which expands a beautiful corol, and emits a very delicate perfume during the night, and not in the day, in its native country, whence its name. Botanical philosophers have not yet explained this wonderful property; perhaps the plant sleeps during the day as some animals do, and its odoriferous glands emit their fragrance only during the expansion of the petals; that is, during its waking hours.

The Geranium tribe has the ſame property of emitting its fragrance during the night only. The flowers of the Cucurbita Lagenaria are ſaid to cloſe when the ſun ſhines upon them. In our climate, many flowers, as Tragopogon and Hibiſcus, cloſe their flowers before the hotteſt part of the day comes on; and the flowers of ſome ſpecies of Cuculalus, and Silene, Viſcous Campion, are cloſed all day; but when the ſun leaves them, they expand, and emit a very agreeable ſcent. On this account, ſuch flowers are called *noctiflori*.

I ſhall cloſe this paper by obſerving, that what is in common language called a bulbous root, is by Linné called the Hybernacle, or Winter-lodge of the young plant; as theſe bulbs in every reſpect reſemble buds, except in their being produced under ground, and include the leaves and flower in miniature, which are to be expanded in the enſuing ſpring. By cautiouſly cutting in the early ſpring through the concentric coats of a tulip-root, longitudinally from the top to the baſe, and taking them off ſucceſſively, the whole flower of the next ſummer's tulip is beautifully ſeen by the naked eye, with its petals, piſtil, and ſtamens: the flowers exiſt in other bulbs, in the ſame manner, as in Hyacinths, but the individual flowers of theſe being leſs, they are not ſo eaſily diſſected, or ſo conſpicuous to the naked eye. In the ſeed of the Nymphæa Nelumbo, the leaves of the plant are ſeen ſo diſtinctly, that Mr. Ferber found out by them to what plant the ſeed belonged. He ſays, that Mariotte firſt obſerved the future flower and foliage in the bulb of a tulip; and he adds, that it is pleaſant to ſee in the buds of the Hepatica and Pedicularis Hirſuta, yet lying in the earth, and in the gems of Daphne Mezereon, and at the baſe of Oſmunda Lunaria, a perfect plant of the future year complete in all its parts.

The retiring of the Tulip to its Hybernacle, or Winter-lodge, is thus beautifully noticed by the admirable poet I have already quoted with such pleasure:

When o'er the cultured lawns and dreary wastes
Retiring Autumn flings her howling blasts,
Bends in tumultuous waves the struggling woods,
And showers their leafy honours on the floods,
In withering heaps collects the flowery spoil,
And each chill insect sinks beneath the soil;
Quick flies fair Tulipa the loud alarms,
And folds her infant closer in her arms;
In some lone cave, secure pavilion, lies,
And waits the courtship of serener skies.—
So, six cold moons, the dormouse charm'd to rest,
Indulgent sleep! beneath thy elder breast,
In fields of fancy climbs the kernel'd groves,
Or shares the golden harvest with his loves.—

XXXI. REFLECTIONS ON THE DIVINE WISDOM AND POWER IN THE MINUTER PARTS OF CREATION.

O Nature, whoſe Elyſian ſcenes diſcloſe
His bright perfections at whoſe word they roſe,
Next to that Pow'r who form'd thee and ſuſtains,
Be thou the great inſpirer of my ſtrains.
Still as I touch the lyre, do thou expand
Thy genuine charms, and guide an artleſs hand;
That I may catch a fire but rarely known,
Give uſeful light though I ſhould miſs renown,
And poring on thy page, whoſe ev'ry line
Bears proof of an intelligence divine,
May feel a heart enrich'd by what it pays,
That builds its glory on its Maker's praiſe.
Woe to the man whoſe wit diſclaims its uſe,
Glitt'ring in vain, or only to ſeduce,
Who ſtudies Nature with a wanton eye,
Admires the work, but ſlips the leſſon by.

COWPER.

O Nature, thy minuteſt works amaze,
Poſe the cloſe ſearch, and loſe our thoughts in praiſe!

BROWNE.

THE animated language of the poet may be adopted, with the greateſt propriety, by the philoſopher, who ſtudies the works of Nature not merely for the gratification of curioſity, or the amuſement of a vacant moment, but for the nobler purpoſe of diffuſing inſtruction, and of teaching his fellow-creatures to adore, as becomes them, the Great Creator, Governor and Preſerver of All. Not he alone is to be eſteemed a benefactor to mankind, who makes a uſeful diſcovery, but he alſo who can point out and recommend an innocent and inſtructive pleaſure. Of this kind are the pleaſures which ariſe from the obſervation of Nature, and that not only in her

greateſt and moſt ſtupendous works, but in thoſe which are ſo wonderfully minute as to be imperceptible by the naked eye. For it is not alone in the radiant orbs above, in their aſtoniſhing magnitude, and regular order, that the Deity is conſpicuous, but in the beautiful ſtructure and colours of a flower or a leaf, in the parts and conformation of the minuteſt inſect, and of thoſe infinite varieties of animalcules, which are the object of microſcopic viſion.

In the 148th Pſalm, not only the angelic choirs, and the whole human race, but even the celeſtial bodies, and all the inanimate world below, are exhorted, by a noble proſopopœia, to praiſe their great Creator: "Praiſe ye the Lord in the heavens; praiſe him in the heights. Praiſe ye him all his angels; praiſe ye him all his hoſts. Praiſe ye him ſun and moon; praiſe him all ye ſtars of light. Praiſe him ye heavens of heavens, and ye waters that are above the heavens. Let them praiſe the name of the Lord; for he commanded, and they were created".—Not that the celeſtial bodies, ſenſeleſs and inanimate as they are, can utter the ſtupendous praiſe of their Creator, but that they inceſſantly exhibit the moſt magnificent diſplay of his attributes and perfections. "The heavens declare the glory of God, and the firmament ſhoweth his handywork".—When theſe, therefore, are exhorted to praiſe God, nothing more can be underſtood, than that Man, whom he made to look erect, and taught alone to contemplate the ſkies [a], ſhould inceſſantly ſeek him in thoſe glorious manifeſtations of omnipotent energy and influence; ſhould conſider him in thoſe unnumbered effects of infinite wiſdom, their prodigious dimen-

[a] Os homini ſublime dedit: cœlúmque tueri
Juſſit, et erectos ad ſidera tollere vultus. OVID.

He with a lofty look did man endúe,
And bade him heav'n's tranſcendent beauties view. SANDYS.

ſions, their regular motions and periods, their admirable diſpoſition and order, and their eminent uſes in illuminating and enlivening the planets and other bodies around them, as well as their reſpective inhabitants, by the vivifying and cheering influence of their light and heat; and, in fine, ſhould aſcribe to God the glory of his power in making ſuch great and illuſtrious bodies, as well as the glory of his wiſdom and goodneſs, in placing and diſpoſing them in ſuch a manner, and ordering their motions with ſuch invariable regularity, that they never claſh nor interfere with each other.

Nor are the contemplations of man confined to the reſplendent orbs on high. By the ſame figure of ſpeech he is invited to the ſtudy of univerſal Nature: "Praiſe ye the Lord from the earth, ye dragons and all deeps; fire and hail, ſnow and vapour, ſtormy wind fulfilling his word; mountains and all hills, fruitful trees and all cedars; beaſts and all cattle, creeping things, and flying fowl".—We do not reſolve this exhortation into the mere beauty and boldneſs of poetical decoration. Fire, hail, ſnow, the elements and meteors; the trees and other plants; the beaſts, birds, inſects, and other tribes of animated nature, with whatever degrees of ſenſe and perception the latter are endued, are in themſelves incapable of praiſing the Divine Being. When they, therefore, are exhorted to praiſe God, we are to underſtand that Man is commanded to inveſtigate their various properties and powers; to conſider their curious ſtructure and conformation, with the admirable ends for which they were created, and to aſcribe that glory, in courſe, to the beneficent Creator, which ſuch wonderful diſplays of goodneſs, wiſdom, and power, muſt naturally demand: "Kings of the earth, and all people; princes and all judges of the earth; both young men and maidens, old men and children; let them praiſe the name of the Lord:

for his name alone is excellent, his glory is above the earth and heaven".

It muſt not here be unnoticed, that the pious author of this Pſalm calls upon inſects alſo, thoſe minuter creatures, to join in the univerſal hymn: intimating thus, that what may ſeem in our eyes to be the meaneſt and moſt contemptible part of the creation, can afford ſubjects of admiration and devotion to the pious and contemplative inquirer: for there can be nothing which the Deity has condeſcended to create, which is, in any reſpect, unworthy the attention of man. The works of Nature are no leſs wonderful in the ſmalleſt than in the largeſt bodies. We may diſcover in the former, as well as in the latter, a kind of *infinite*, that at once aſtoniſhes and confounds. How wonderful to find in a ringworm, as in an elephant or a whale, members perfectly organized; to diſcover a head, a body, legs, and feet, like thoſe of the largeſt animals! In each part of theſe living atoms are muſcles, nerves, veins, arteries, and blood. This blood is furniſhed with ſpirits, ramified parts, and humours. The humours again are made up of various particles; ſo that thought is loſt in tracing the progreſſion of a compoſition ſo infinitely minute. In a word, the more accurate our inquiries into this ſubject, the greater reaſon ſhall we have for aſſenting to the propriety of the obſervation, that the Supreme Being is, indeed, "*maximus in minimis*—the greateſt in the leaſt".

The microſcope diſplays to us, in each object, as it were, a thouſand others which eſcaped our knowledge. Yet, in every object diſcovered by this inſtrument, others ſtill remain unſeen, which the microſcope itſelf can never produce. What wonders ſhould we ſee if we could continually improve thoſe glaſſes, which are invented for the aſſiſtance of our rude and feeble ſight! But we may ſupply, by our

imagination, the defect of our eyes, and make it ſerve as a microſcope to repreſent in each atom a thouſand new and inviſible worlds. It cannot, however, inceſſantly figure to us new diſcoveries in bodies ſo infinitely ſmall. The taſk would be too painful. It is neceſſary that the imagination ſhould ſtop its inquiries, and leave, in the minuteſt organ, a thouſand wonders undiſcovered ſtill. Let it ſuffice, that a ſingle glance will enable us to diſcover in a ſmall animal, even in an ant, more than we can find in the ſun; a wiſdom and power delighting to ſhow itſelf in forming and finiſhing the meaneſt of its works.

Myriads of creatures (each too nicely ſmall
Bare ſenſe to reach) for thy inſpection call.
In animalcules, germs, ſeeds, and flow'rs
Live, in their perfect ſhapes, the little pow'rs.
Vaſt trees lie pictur'd in their ſtend'reſt grains:
Armies one wat'ry globule contains.
The artificial convex[a] will reveal
The forms diminutive that each conceal;
Some, ſo minute, that, to their fine extreme,
The mite a vaſt leviathan will ſeem:
That yet of organs, functions, ſenſe partake,
Equal with animals of largeſt make,
In curious limbs and clothing they ſurpaſs
By far the comelieſt of the bulky maſs.
A world of beauties! that thro' all their frame,
Creation's grandeſt miracles proclaim.

* * * * *

Search the leaſt path Creative Pow'r has trod
How plain the footſteps of th' apparent God!
His art could organs, ſtrength, and ſenſe implant
In the ſmall agile fly and reptile ant.
In the mean mite, ſo much minuter ſtill,
Thy finger's preſſing point may millions kill.

[a] Some of theſe amazing inſtruments magnify the cube, or ſolid ſquare of an object, above 500 millions of times. Thoſe viewed by the ſolar microſcope may be extended to almoſt any dimenſions.

Mark'd by the magnifying chryſtal's aid,
In ev'ry place what proofs will ſtand diſplay'd!
Lo! from the ſtagnant pool one drop obtain;
Of inſects this includes a ſumleſs train:
Buoy'd in the little pool they friſk and play,
Pleas'd with their ſhort exiſtence of a day.
That blue with which the gloſſy plum is grac'd,
That gives ſuch poignant pleaſure to its taſte,
Or azures o'er the damſon's velvet rind,
A group of ſmalleſt animals we find.
The little gnat, in beauties, may compare
With all his rival brothers of the air;
Tranſparent feathers, purple, green, and gold,
His wings, ſmall feet, and gay-fring'd tail enfold;
Four ſharpen'd ſpears his head with weapons arm,
And his pearl'd eyes[a] with livelieſt graces charm.

* * * * *

Thy microſcopic glaſs admiring bring,
And view the humble hornet's ſharpen'd ſting;
Then on the ſlend'reſt needle turn thy eye,
And the vaſt difference in their points deſcry:
This view'd, more poliſh'd ſeems, acuter far;
That, rough as from the forge ſome blunted bar.
God's ſmalleſt work all human ſkill degrades,
Foils the loſt man, and ſinks his worth in ſhades.

BROWNE.

By the microſcope, indeed, we are enabled to perceive, that the minuteſt works of Nature are adorned with the moſt conſummate elegance and beauty. There are ſuch inimitable gildings and embroideries in the ſmalleſt ſeeds of plants, but eſpecially in the parts of animals, in the head and eye of a ſmall fly; ſuch accurate ſymmetry, moreover, in the frame of the moſt minute creature, ſuch as a flea, a louſe, or a mite; as it would be impoſſible

[a] Theſe are compoſed of ſeveral hundred little hemiſpheres, or, in reality, ſo many diſtinct eyes; which have ſuch a power of magnifying, and are of ſuch a wonderful ſtructure, in numbers of the minuteſt inſects, that they are capable herewith to diſcover objects, many thouſand times leſs than themſelves.

for any mortal to conceive, without a previous inſpection of them. But I ſhall not, at preſent, enter any further into the wonderful variety of particulars which might be collected on this ſubject. I ſhall confine myſelf to ſuch reflections as the laſt lines of the above poetical extract muſt naturally ſuggeſt; namely, the very ſtriking contraſt which the microſcope diſcovers between the works of Nature and the efforts of Art. Nature, it is obſerved, is not leſs remarkable for the accuracy and beauty of all her works than for variety and profuſion. Defects, on the contrary, are always diſcovered in the works of Art, when examined with a microſcope; but the cloſe inſpection of a leaf of a flower is like removing a veil from the face of beauty. The fineſt needle ever poliſhed, and pointed by the moſt ingenious artiſt, appears, when it is viewed by the ſolar microſcope, quite obtuſe; while the ſting of a bee, however magnified, ſtill retains all its original acuteneſs of termination. The moſt accurate engravings or emboſſments ſeem ſuch rude and deformed work, when thus magnified, as if they had been wrought by a mattock or a trowel; and the threads of the fineſt cambric appear like packthread, and ſeem rather the workmanſhip of a baſketmaker, than the beautiful production of the loom. On the contrary, the ſerrated borders of the petal of a flower, and the fringe on the wing of a fly, diſplay an accuracy of delineation, which no pencil can rival. Such an infinite difference is there between the exquiſite ſkill of Nature and the comparative rudeneſs and imperfection of Art [a].

[a] It is a great mortification to the vanity of man, that his utmoſt art and induſtry can never equal the meaneſt of Nature's productions, either for beauty or value. Art is only the under workman, and is employed to give a few ſtrokes of embelliſhment to thoſe ſpecies, which came from the hand of the maſter. Some of the drapery may be of his drawing; but he is not allowed to touch the principal figure. Art may make a ſuit of clothes: but Nature muſt produce a man. HUME.

I think, therefore, that I cannot better conclude this paper, than by obſerving, what an inconſiſtency it is in the character of a rational being, to be tranſported with the workmanſhip of a poor mortal, and to feel no rapture in ſurveying the inimitable performances, in which the hand of Deity is ſo viſible. The ſubject, moreover, may ſuggeſt to us a becoming caution, not to treat with contemptuous ſuperiority, and much leſs with wantonneſs and cruelty, the meaneſt of thoſe creatures, to the formation and decoration of which God himſelf has been ſo attentive: for if we exalt our views to the celeſtial orbs above, and conceive the poſſible exiſtence, in other worlds, of beings infinitely ſuperior to us in dignity and excellence, yet ſtill infinitely remote from the Deity in perfection; how comparatively minute and contemptible may we appear to them! But not to wander in the fields of imagination, with what emphaſis and propriety has the Pſalmiſt taught us to exclaim, "When I conſider the heavens, the work of thy fingers, the moon and the ſtars which thou haſt ordained, what is man that thou art mindful of him, and the ſon of man that thou viſiteſt him"?

XXXII. FURTHER REFLECTIONS ON THE MINUTE WONDERS OF CREATION.

Nature's *great* works no diſtance can obſcure,
No *ſmallneſs* her near objects can ſecure;
We've learn'd the curious ſight to preſs
Into the privateſt receſs
Of her imperceptible littleneſs!
We've learn'd to read her ſmalleſt hand,
And well begun her deepeſt ſenſe to underſtand.

COWLEY.

In an inſect or a flower,
Such microſcopic proofs of ſkill and power,
As hid from ages paſt, God now diſplays,
To combat atheiſts with in modern days.

COWPER.

IN my preceding paper, I conſidered, in general, the great ſuperiority of the works of Nature over thoſe of Art, as particularly diſcernible in the objects of microſcopic viſion. This is a ſubject of contemplation, of which the ancients had no conception, and of which, in courſe, they can afford us no poetical illuſtrations. It was reſerved for modern philoſophy, moreover, to invent the means of bringing creatures, imperceptible to the naked eye, under our cogniſance and inſpection; and to furniſh the contemplative poets of our age with new ſubjects of adoration.

Gradual—what numerous kinds deſcend,
Evading ev'n the microſcopic eye!
Full Nature ſwarms with life; one wondrous maſs
Of animals, or atoms organized,
Waiting the vital breath, when parent Heaven
Shall bid his ſpirit blow. The hoary fen,
In putrid ſtreams, emits the living cloud

Of peſtilence. Thro' ſubterranean cells,
Where ſcorching ſunbeams ſcarce can find a way,
Earth animated heaves. The flowery leaf
Wants not its ſoft inhabitants. Secure,
Within its winding citadel, the ſtone
Holds multitudes. But chief the foreſt-boughs,
That dance unnumbered to the playful breeze,
The downy orchard, and the melting pulp
Of mellow fruit, the nameleſs nations feed
Of evaneſcent inſects. Where the pool
Stands mantled o'er with green, inviſible,
Amid the floating verdure millions ſtray.
Each liquid too, whether it pierces, ſooths,
Inflames, refreſhes, or exalts the taſte,
With various forms abounds. Nor is the ſtream
Of pureſt cryſtal, nor the lucid air,
Though one tranſparent vacancy it ſeem,
Void of their unſeen people. Theſe, conceal'd
By the kind art of forming Heaven, eſcape
The groſſer eye of man: for, if the worlds
In worlds inclos'd ſhould on his ſenſes burſt,
From cates ambroſial, and the nectar'd bowl,
He would abhorrent turn; and in dead night,
When ſilence ſleeps o'er all, be ſtunn'd with noiſe.

THOMSON.

The word *animalcule*, the general name of theſe creatures, is a diminutive of *animal*; expreſſing ſuch a minute creature, as is either ſcarcely, or not at all, to be diſcerned by the naked eye. Such are thoſe numerous inſects, which crowd the water in the ſummer months; changing it ſometimes of a deep or pale red colour, ſometimes of a yellow, &c. Theſe often ſeem to be of the ſhrimp kind, and the moſt common one is called by Swammerdam, *pulex aquaticus arboreſcens*. Their concourſe at this time, as Mr. Derham obſerves, is for the purpoſe of propagating their ſpecies; and he adds, that they afford a comfortable nouriſhment to many water animals. The green ſcum, on the top of ſtagnant waters, is

often nothing elſe but prodigious numbers of another ſmaller order of animalcules, which, in all probability, ſerve for food to the *pulices aquatici*.

The microſcope diſcovers legions of animalcules in moſt liquors, as water, wine, vinegar, beer, dew, &c. In the Philoſophical Tranſactions we have obſervations of the animalcules in rain-water, in ſeveral chalybeat waters, and in infuſions of pepper, bay-berries, oats, barley, and wheat.

Thoſe who have made the moſt minute and accurate reſearches into the natures of the ſeveral objects ſubjected to their ſenſes, have found that the ſubſtances upon which they employed their curioſity, were often quite different from what they ſeemed to be at firſt view. Thus, for inſtance, the whole earth has been found repleniſhed with an inexhauſtible ſtore of what we ſhould leaſt of all ſuſpect—an infinite number of animalcules floating in the air we breathe, ſporting in the fluids we drink, or adhering to the ſeveral objects we ſee and handle.

Far leſs than mites, on mites they prey;
Minuteſt things may ſwarms contain;
When o'er your ivory teeth they ſtray,
Then throb your little nerves with pain.

Fluids, in drops, minutely ſwell;
Theſe ſubtile beings each contains;
In the ſmall ſanguine globes they dwell,
Roll from the heart, and trace the veins.

Through every tender tube they rove,
In finer ſpirits ſtrike the brain;
Wind quick through every fibrous grove,
And ſeek, through pores, the heart again.

SAVAGE.

The conjectures and hypotheſes relating to the production, generation, ſtructure, and uſes of theſe animalcules, have been as various as were ever contrived by caprice, or embraced by credulity. But

not to bewilder my readers in these labyrinths, I will confine my observations to actual discoveries. By the assistance of the microscope, we not only perceive that such animalcules exist, but are also enabled, in some degree, to determine their shapes, and the various peculiarities of their motion. In a word, the contemplation of animalcules has made the ideas of infinitely small bodies familiar to us. A mite was anciently thought the limit of littleness.

The polish'd glass, whose small convex
Enlarges to ten millions of degrees
The mite, invisible else, of Nature's hand
Least animal; and shows what laws of life
The cheese-inhabitants observe, and how
Fabric their mansions in the harden'd milk,
Wonderful artists! J. PHILIPS.

But we are not now surprised to be told of animals twenty-seven millions of times smaller than a mite.

Animalcules may be considered as visible, invisible, or microscopical.—The *visible*, or such as may be discerned by the naked eye, are mites, divers species of insects, reptiles, and other vermin.—The *invisible*, which are a species or order of animalcules *supposed* by naturalists, are such as escape the cognisance even of the best microscopes. In relation to these, they give many probable conjectures; and, indeed, reason and analogy afford some support to the existence of infinite imperceptible animalcules. The naked eye, it has been observed, takes in from the elephant to the mite; but there commences a new order reserved only for the microscope, which comprehends all these from the mite, to those twenty-seven millions of times smaller; and this order cannot be yet said to be exhausted, if the microscope be not arrived at its last perfection.—The *microscopical* animalcules are such as are discoverable only by the assistance of a large magnifier: these, according

to ſome, come under the denomination of inviſible animalcules.

The extreme minuteneſs of theſe animalcules conceals them from the human eye unarmed. This is one of the great wonders of the modern philoſophy. An object, a thouſand times too little to be able to affect our ſenſe, would, one would have thought, have been perfectly ſecure from our inſpection. Yet we have extended our views over animals to whom theſe would be mountains. And it is ſtrictly true, that moſt of our microſcopical animalcules are ſo inconceivably ſmall, that many thouſands of them may dance on the point of a needle.

With reſpect to their ſtructure and economy, animalcules are found of divers ſorts; ſome formed like fiſh, others reptile, others hexapedal, ſome horned, &c. In ſeveral kinds, however ſmall, it is eaſy to diſcover the form of their mouths, their proboſcides, horns, &c. with the motions of their hearts, lungs, and other parts. Now, as every animalcule is an organized body, how delicate and ſubtile muſt the parts be, that are neceſſary to conſtitute it, and to preſerve its vital actions! It is difficult to conceive how, in ſuch a narrow compaſs, there ſhould be contained a heart to be the fountain of life, muſcles neceſſary to its motions, glands for the ſecretion of its fluids, a ſtomach and bowels to digeſt its food, and other innumerable members, without which an animalcule cannot ſubſiſt. But ſince every one of theſe members is alſo an organic body, they muſt have likewiſe parts neceſſary to their action: for they conſiſt of fibres, membranes, coats, veins, arteries, nerves, and an almoſt infinite number of fine tubes like thoſe, whoſe minuteneſs ſeems to exceed all efforts of imagination. But there are ſome parts that ought almoſt to be infinitely leſs than theſe, as the fluids that flow along theſe fine tubes,

the blood, lymph, and animated ſpirits, whoſe ſubtilty, even in large animals, is incredible.

The celebrated naturaliſt Leewenhoeck, calculates that a thouſand millions of animalcules, which are diſcovered in common water, are not altogether ſo large as a common grain of ſand. Upon examining the male ſperm of various animals, he diſcovered in many, infinite numbers of animalcules, not larger than thoſe above-mentioned. In the milt of a ſingle cod, there are more animals than there are men upon the whole earth; and yet a grain of ſand is bigger than four millions of them. The white matter alſo, which ſticks to our teeth, abounds with animalcules of various figures, to which vinegar is fatal; and it is known that vinegar contains animalcules in the ſhape of eels. In ſhort, according to this author, there is ſcarce any thing that corrupts, without producing animalcules. Animalcules, moreover, are ſaid to be the cauſe of various diſorders. The itch, from ſeveral experiments, is affirmed to be a diſorder ariſing from the irritations of a ſpecies of animalcules found in the puſtules of that ailment; whence the communication of it by contact from one perſon to another is eaſily conceived, as alſo the reaſon of the cure being effected by cutaneous applications.

There is one remarkable circumſtance, that we muſt not paſs over in our contemplation of theſe minuter animals; which is, that they are found proportionably much ſtronger, more active and vivacious, than large ones. The ſpring of a flea in its leap, how vaſtly does it outſtrip any thing of which greater animals are capable! A mite, how vaſtly ſwifter does it run than a racehorſe! M. de l'Iſle has given the computation of the velocity of a little creature ſcarce viſible by its ſmallneſs, which he found to run three inches in half a ſecond: now, ſuppoſing its feet to be the fiftieth part of a line, it muſt make 500 ſteps in the ſpace of three inches: that is, it

muſt ſhift its legs 500 times in a ſecond, or in the ordinary pulſation of an artery.

How ſweet to muſe upon His ſkill diſplay'd
(Infinite ſkill!) in all that he has made.
To trace in Nature's moſt minute deſign,
The ſignature and ſtamp of Power Divine;
Contrivance exquiſite expreſs'd with eaſe,
Where unaſſiſted ſight no beauty ſees;
The ſhapely limb and lubricated joint
Within the ſmall dimenſions of a point;
Muſcle and nerve miraculouſly ſpun,
His mighty work who ſpeaks, and it is done;
Th' invifible in things ſcarce ſeen reveal'd;
To whom an atom is an ample field. COWPER.

In a word, the microſcope endues us, as it were, with a new ſenſe; unfolds the amazing operations of Nature, and diſplays to us wonders unimagined by former ages.

Who, a thouſand years ago, would have thought it poſſible to diſtinguiſh myriads of living creatures in a ſingle drop of water? That the purple tide of life, and even the globules of the blood ſhould be ſeen diſtinctly, rolling through veins and arteries ſmaller than the fineſt hair? That not only the exterior form, but even the internal ſtructure of the bowels, and the motion of the fluids in a gnat or louſe, ſhould be rendered viſible? Or, that numberleſs ſpecies of creatures ſhould be made objects of viſion, though ſo minute, that a million of them are leſs than a grain of ſand?

Theſe are noble diſcoveries, on which a new philoſophy has been raiſed, that enlarges the capacity of the human underſtanding, and affords more ſublime and juſt ideas than mankind had before, of the infinite power, wiſdom, and goodneſs of the Great Creator.

It was an obſervation of the excellent Mr. Boyle, "that his wonders dwelt not ſo much on Nature's

clocks as on her watches". And, indeed, if we compare the ſtructure of an elephant with that of a mite, we ſhall perceive the juſtneſs of his remark. With whatever degree of ſurpriſe, or even of terror, we may at firſt conſider the huge bulk and prodigious ſtrength of the elephant, we ſhall find our aſtoniſhment ſtill greater, if we attentively examine the minute parts of the mite: for the latter has more limbs than the elephant; each of them (as I obſerved before) furniſhed with veins and arteries, nerves, muſcles, tendons, and bones: it has eyes, a mouth, and a proboſcis too (as well as the elephant) to take in its nouriſhment: a heart, moreover, to propel the circulation of the blood, a brain to ſupply nerves in every part, and organs of generations as perfect as in the largeſt animal. Now, if the extreme minuteneſs of theſe parts is not merely ſurpriſing, but far above our utmoſt conception, what ſhall we ſay to thoſe various ſpecies of animalcules, to which the mite itſelf, in ſize, is, as it were, an elephant?

However inconceivable it may appear, it is yet a fact, that a mite upon a cheeſe is as large and conſiderable, in proportion, as a man upon the earth. The little inſects that feed upon the leaves of peach-trees, are no bad repreſentation of oxen grazing in large paſtures; and the animalcules, in a drop of water, ſwim about with as much freedom as whales do in an ocean. In a word, they have all equal room in proportion to their bulk.

Nor power alone confeſs'd in grandeur lies,
The glittering planet, or the painted ſkies;
Equal, the elephant's or emmet's dreſs,
The wiſdom of Omnipotence confeſs;
Equal the cumbrous whale's enormous maſs,
With the ſmall inſect in the crowded graſs;
The mite that gambols, in its acid ſea,
In ſhape a porpus, tho' a ſpeck to thee!

E'en the blue down the purple plum ſurrounds,
A living world, thy failing ſight confounds!
To thee a peopled habitation ſhows,
Where millions taſte the bounty God beſtows. BOYSE.

The diſcoveries of the microſcope ſuggeſt to us this important truth, that our ideas of matter, magnitude, and minuteneſs, are merely comparative. They are taken from ourſelves and the things around us, beyond which, if we endeavour to extend them, they become very indiſtinct. The beginnings and endings, exceſſive greatneſs or extreme littleneſs, of things, are to us all perplexity and confuſion.

"Let a man (ſays Mr. Addiſon[a]) try to conceive the different bulk of an animal which is twenty, from another which is a hundred times leſs than a mite; or to compare, in his thoughts, a length of a thouſand diameters of the earth with that of a million; and he will quickly find that he has no different meaſures in his mind, adjuſted to ſuch extraordinary degrees of grandeur or minuteneſs. The Underſtanding, indeed, opens an infinite ſpace on every ſide of us; but the Imagination, after a few faint efforts, is immediately at a ſtand, and finds itſelf ſwallowed up in the immenſity of the void that ſurrounds it. Our Readers can purſue a particle of matter through an infinite variety of diviſions; but the Fancy ſoon loſes ſight of it, and feels in itſelf a kind of chaſm, that wants to be filled with matter of a more ſenſible bulk. We can neither widen nor contract the faculty to the dimenſions of either extreme. The object is too big for our capacity, when we would comprehend the circumference of a world, and dwindles into nothing when we endeavour after the idea of an atom".

But although the powers of the imagination be thus defective, the underſtanding is convinced by

[a] Spectator, No. 420.

demonſtration, and beholds this variety of wonders with aſtoniſhment and awe. Whether, with a Newton or a Herſchel, we take the teleſcope, and compute the ſtupendous magnitude and velocity of a planet; or, with a Leewenhoeck or a Baker, ſurvey, through a microſcope, the ſtructure and conformation of a mite; in each we are compelled to admire and adore the pervading wiſdom and energy of the Creator:

In the Vaſt and the Minute
The unambiguous footſteps of the God,
Who gives its luſtre to an inſect's wing,
And wheels his throne upon the rolling worlds.

COWPER.

XXXIII. A VIEW OF THE INSECT TRIBES.

We wonder at a thouſand inſect forms,
Theſe hatch'd, and thoſe reſuſcitated worms,
New life ordain'd, and brighter ſcenes to ſhare,
Once prone on earth, now buoyant upon air.

COWPER.

INSECTS exhibit ſuch an immenſe variety in figure, colour, and diſpoſition of parts, that naturaliſts have found it neceſſary to arrange them into different tribes or families, diſtinguiſhed from one another by certain peculiarities in the ſtructure of their bodies.

The moſt general diviſion of inſects is derived from the circumſtance of their having or wanting wings, and from the number and ſubſtances of which theſe inſtruments of motion are compoſed. They are diſtinguiſhed from all other animals by many pe-

culiarities of form. None of the other claſſes have more legs than four. But moſt inſects have ſix; and many of them have eight, ten, fourteen, ſixteen, eighteen, and even a hundred legs. Beſide the number of legs, inſects are furniſhed with *antennæ*, or feelers. Theſe feelers, by which they grope and examine the ſubſtances they meet with, are compoſed of a great number of articulations or joints. Linné, and other naturaliſts, maintain, that the uſes of theſe feelers are totally unknown. But the ſlighteſt attention to the manner in which ſome inſects employ their feelers will ſatisfy us of at leaſt one uſe they derive from theſe organs. When a wingleſs inſect is placed at the end of a twig, or in any ſituation where it meets with a vacuity, it moves the feelers backward and forward, elevates, depreſſes, and bends them from ſide to ſide, and will not advance further, leſt it ſhould fall. If a ſtick, or any other ſubſtance, be placed within reach of the feelers, the animal immediately applies them to this new object, examines whether it is ſufficient to ſupport the weight of its body, and inſtantly proceeds in its journey. Though moſt inſects are provided with eyes, yet the lenſes of which they conſiſt are ſo ſmall and convex, that they can ſee diſtinctly but at ſmall diſtances, and, of courſe, muſt be very incompetent judges of the vicinity or remoteneſs of objects. To remedy this defect, they are provided with feelers, which are perpetually in motion while the animals walk. By the ſame inſtruments, they are enabled to walk with ſafety in the dark.

No other animals but the inſect tribes have more than two eyes; but ſome of them have four, and others, as the ſpider and ſcorpion, have eight eyes. In a few inſects, the eyes are ſmooth; in all the others, they are hemiſpherical, and conſiſt of many thouſand diſtinct lenſes. The eyes are abſolutely immoveable: but this defect is ſupplied by the vaſt

number of lenſes, which, from the diverſity of their poſitions, are capable of viewing objects in every direction. By the ſmallneſs and convexity of theſe lenſes, which produce the ſame effect as the object glaſs of a microſcope, inſects are enabled to ſee bodies that are too minute to be perceived by the human eye. Another peculiarity deſerves alſo our notice. No animals, except a numerous tribe of four-winged inſects, have more than two wings.

With regard to ſex, quadrupeds, birds, and fiſhes, are diſtinguiſhed into males and females. But the bee and the ant furniſh examples of neuters, which are abſolutely barren: and the earthworm, and ſeveral ſhell animals, are hermaphrodite, each individual poſſeſſing the prolific powers of both male and female.

It is likewiſe remarkable, that all winged inſects undergo three metamorphoſes or changes of form: the egg is diſcharged from the body of the female in the ſame manner as in other oviparous animals. By a wonderful inſtinct, theſe ſeemingly ſtupid creatures uniformly depoſit their eggs on ſuch animal or vegetable ſubſtances as furniſh proper food for the worm or caterpillar, that is to be hatched by the heat of the ſun. The worm or caterpillar is the firſt ſtate. The bodies of caterpillars are ſoft and moiſt. They have no wings, and are totally deprived of the faculty of generation. After continuing for ſome time in this reptile ſtate, they are transformed into a chryſalis, which is drier and harder than the caterpillar. The chryſaliſes of ſome inſects are naked, and thoſe of others are covered with a ſilken web, ſpun by the animals before their change is completed. In this ſtate, many of them lie motionleſs, and ſeemingly inanimate, during the whole winter. When the ſpring or ſummer heats return, they burſt from their laſt priſon, and, from vile reptiles, are tranſformed into beautiful flies. In this perfect ſtate they

are exceedingly active, fly about in queſt of their mates, and, after propagating their ſpecies, the females depoſit their eggs, and the ſame circle of animation and change perpetually goes round.

Behold the inſect race, ordain'd to keep
The lazy ſabbath of a half-year's ſleep;
Entomb'd, beneath the filmy web they lie,
And wait the influence of a kinder ſky.
When vernal ſunbeams pierce their dark retreat,
The heaving tomb diſtends with vital heat;
The full-form'd brood, impatient of their cell,
Start from their trance, and burſt their ſilken ſhell;
Trembling, awhile they ſtand, and ſcarcely dare
To launch at once upon the untried air:
At length aſſur'd, they catch the favouring gale,
And leave their ſordid ſpoils, and high in ether ſail.

BARBAULD.

Wak'd by his warmer ray, the reptile young
Come wing'd abroad; by the light air upborn,
Lighter, and full of ſoul. From every chink,
And ſecret corner, where they ſlept away
The wintry ſtorms; or riſing from their tombs,
To higher life; by myriads, forth at once,
Swarming they pour; of all the vary'd hues
Their beauty-beaming parent can diſcloſe.
Ten thouſand forms! ten thouſand different tribes!
People the blaze. To ſunny waters ſome
By fatal inſtinct fly; where on the pool
They, ſportive, wheel; or, ſailing down the ſtream,
Are ſnatch'd immediate by the quick-ey'd trout,
Or darting ſalmon. Through the greenwood glade
Some love to ſtray; there lodg'd, amus'd and fed,
In the freſh leaf. Luxurious, others make
The meads their choice, and viſit every flower,
And every latent herb: for the ſweet taſk,
To propagate their kinds, and where to wrap,
In what ſoft beds, their young yet undiſclos'd,
Employs their tender care. Some to the houſe,
The fold, and dairy, hungry, bend their flight;
Sip round the pail, or taſte the curdling cheeſe:

Oft, inadvertent, from the milky ſtream
They meet their fate; or, weltering in the bowl,
With powerleſs wings around them wrapt, expire.
THOMSON.

There is another peculiarity in the ſtructure of inſects. They are deprived of bones. But that defect is ſupplied, in ſome, by a membraneous or muſcular ſkin, and, in others, by a cruſtaceous or horny covering. In this circumſtance, inſects reſemble the ſhell-animals, whoſe bones conſtitute the external parts of their bodies.

In general, the bodies of inſects are compoſed of a head, trunk, and abdomen. The head is commonly attached to the trunk by a joint or articulation. Beſide eyes, feelers, and mouth, the heads of ſome inſects are furniſhed with *palpi* fixed to the mouth; and they are either four or ſix in number. Each of them conſiſts of two, three, or four joints, and are often miſtaken for the *antennæ*, or feelers. Theſe inſtruments ſeem to ſerve the animals inſtead of hands; for they employ them to bring the food to their mouths, and to keep it ſteady while eating. It is aſſerted by Linné, and other naturaliſts, that the heads of inſects are deſtitute of brains, noſtrils, and ears. The minuteneſs of the animals under conſideration may have hitherto prevented us from diſtinguiſhing theſe organs. If they want a brain, it is certain that their ſenſe of ſeeing is acute; and we know that they are amply ſupplied with nerves, which produce the ſame effects as the brain in larger animals. If they are deprived of noſtrils, the ſlighteſt attention muſt convince us, that ſome of them poſſeſs the ſenſe of ſmelling in a very high degree. Upon any other ſuppoſition, how ſhould the different ſpecies of flies, the moment they eſcape from the chryſalis ſtate, diſtinguiſh, and directly approach, the different animal and vegetable ſubſtances Nature

has deſtined for their reſpective nouriſhment? A piece of meat is no ſooner expoſed to the air than it is covered with fleſh flies, upon which they both feed and depoſit their eggs. Without this ſenſe, how ſhould waſps, and other flies, be allured from conſiderable diſtances into bottles encruſted with honey or molaſſes? Theſe, and ſimilar actions, cannot be effects of ſight; for the diſtance, the minuteneſs, and frequently the poſition of the food, render it impoſſible for the eye to diſcover thoſe ſubſtances to which they inſtantly reſort.—With regard to hearing, it is more difficult to determine whether inſects be endowed with this ſenſe. We can judge of it, not by the knife of the anatomiſt, but by the affections and motions of the animals themſelves. From ſeveral trials made on houſe-flies, it is thought that if theſe animals are really deprived of ears, they are endowed with an analogous ſenſe, though we are ignorant of its ſituation.

Naturaliſts have limited the ſenſes of inſects to thoſe of ſeeing and feeling. But the above remarks render it probable that flies poſſeſs likewiſe the ſenſes of ſmelling and of hearing: neither ſhould the ſenſe of taſte be denied them; for, though they may be aſſiſted by ſmelling to diſcover and ſelect their food, we cannot ſuppoſe that Nature has denied them the pleaſure which other animals ſo univerſally derive from eating. Beſides, an agreeable ſenſation, ſimilar to that of taſte, muſt accompany an action which removes the pain ariſing from hunger.

The mouth of inſects is generally placed in the under part of the head; but, in ſome, it is ſituate in the breaſt. The jaws, inſtead of being horizontal, are often tranſverſe, and furniſhed with teeth. The greater number of winged inſects are provided with a proboſcis or trunk, an inſtrument by which they extract the juices from animal or vegetable ſubſtances. The proboſcis of inſects is a machine of

a very complicated nature. In butterflies, the proboſcis is ſituate preciſely between the two eyes. Though ſome of them exceed three inches in length, they occupy but a ſmall ſpace. When a butterfly is not in queſt of food, the proboſcis is rolled up in a ſpiral form, ſimilar to that of a watch-ſpring, each ſucceſſive ring covering the one which precedes. The ſubſtance of the proboſcis has ſome reſemblance to that of horn. It tapers from the baſe to the extremity. It is compoſed of two ſimilar and equal parts, each of which is concave, and, when joined, form three diſtinct tubes. Reaumur has rendered it probable, that theſe tubes enable the animals to extract the juices of plants, to conduct air into their bodies, and to convey the ſenſation of ſmelling. Hence the proboſcis of inſects is an inſtrument which ſerves them for a mouth, a noſe, and a windpipe.

The upper part of the trunk or body of inſects is called the thorax, and the under part the abdomen or belly. The abdomen contains the ſtomach and other viſcera. It conſiſts of ſeveral rings or ſegments, and is perforated with ſpiracula, or tubes, which ſupply the want of lungs. The abdomen is terminated by the tail, which, in ſome inſects, is armed with a ſting, a forceps, a briſtle, or a kind of claw with a moveable thumb.

The legs are compoſed of three parts, connected to each other by joints, and repreſent the thighs, ſhanks, ankles, and feet of larger animals.

The wings of inſects are ſo diverſified in number, conſiſtence, and colour, that Linné has made them the foundation of the ſeven orders or diviſions into which he divides this numerous claſs of animals. Some inſects are furniſhed with four, and others with two wings, and ſome of them are entirely deſtitute of theſe inſtruments of motion.

The firſt order Linné diſtinguiſhes by the name of *coleoptera*, or thoſe inſects with four wings whoſe

upper pair conſiſt of a hard, cruſtaceous, or horny ſubſtance. Theſe cover and defend the under pair, which are of a more ſoft and flexible texture. This order comprehends the whole of what is properly called *ſcarabaei*, or the beetle tribe. Like other winged inſects, all the beetles live for ſome time in the form of caterpillars, or grubs:

See the proud giant of the beetle race;
What ſhining arms his poliſh'd limbs enchaſe!
Like ſome ſtern warrior formidably bright
His ſteely ſides reflect a gleaming light:
On his large forehead ſpreading horns he wears,
And high in air the branching antlers bears:
O'er many an inch extends his wide domain,
And his rich treaſury ſwells with hoarded grain.

BARBAULD.

It is here worthy of remark, that the ſame animals, when in the ſtate of caterpillars, live in a different manner, and feed on ſubſtances of a very different kind from thoſe they conſume after their tranſformation into flies. The caterpillars of the garden-beetle, cockchafer, &c. lead a ſolitary life under ground, and conſume the roots of plants. Thoſe of others feed upon putrid carcaſſes, every kind of fleſh, dried ſkins, rotten wood, the dung of men and quadrupeds, and the ſmall inſects called pucerons, or vine-fretters. But after their transformation into flies, many of the ſame animals, which formerly fed upon dung and putrid carcaſſes, are nouriſhed by the pureſt nectareous juices extracted from fruits and flowers. The creatures themſelves, with regard to what may be termed individual animation, have ſuffered no alteration. But the fabric of their bodies, their inſtruments of motion, and the organs by which they take their food, are materially changed. This change of ſtructure, though the animals retain their identity, produces the greateſt

diverſity in their manners, their economy, and the powers of their bodies. In the caterpillar ſtate, theſe animals are extremely voracious, and, in many inſtances, acquire a greater magnitude than they poſſeſs after transformation; but they are incapable of multiplying their ſpecies, and of receiving nouriſhment from the ſame kinds of food. Beſides, many caterpillars, previous to their transformation, live even in a different element. The ephemeron fly, when in the caterpillar ſtate, lives no leſs than three years in the water, and extracts its nouriſhment from earth and clay. After transformation, this animal ſeldom exiſts longer than one day, during which the ſpecies is propagated, and myriads of eggs are depoſited on the ſurface of the water. Theſe eggs produce worms or caterpillars, and the ſame proceſs goes perpetually round.

The ſecond order of inſects, denominated *hemiptera*, have likewiſe four wings. But the upper pair, inſtead of being hard and horny, rather reſemble fine vellum. They cover the body horizontally, and do not meet in a direct line, forming a ridge or future, as in the beetle tribe. The whole of this order are furniſhed with a proboſcis or trunk for extracting their food.

This order comprehends ſeveral genera or kinds, ſome of which I ſhall mention in a curſory manner. —The *blatta*, or cockroach, is an animal which avoids the light, and is particularly fond of meal, bread, putrid bodies, and the roots of plants. It frequents bakers ſhops and cellars, and flies the approach of danger with great ſwiftneſs.—The head of the *mantis*, or camel-cricket, appears, from its continual nodding motion, to be ſlightly attached to the thorax. This inſect is regarded by the Africans as a ſacred animal; becauſe it frequently aſſumes a praying or ſupplicating poſture, by reſting on its hind feet, and elevating and folding the firſt pair.—

The *gryllus* comprehends a number of ſpecies, ſome of which are called graſshoppers, others locuſts, and others crickets. The caterpillars of the grylli, have a great reſemblance to the perfect inſects, and, in general, live under ground. Many of theſe inſects feed upon the leaves of plants. Others, which live in houſes, prefer bread, and every kind of farinaceous ſubſtance.—The foreheads of ſeveral of the genus, called *fulgora*, or fire-fly, eſpecially of thoſe that inhabit China, and other hot climates, emit a very lively ſhining light during the night, which often alarms thoſe who are unacquainted with the cauſe of the appearance.—To this inſect Thomſon alludes in his view of the torrid zone:

From Menam's orient ſtream, that nightly ſhines
With inſect lamps.

And Mrs. Barbauld:

Some ſhoot like living ſtars, athwart the night,
And ſcatter from their wings a vivid light,
To guide the Indian to his tawny loves,
As thro' the woods with cautious ſteps he moves.

The caterpillars of ſome of the genus called *cicada*, or flea-locuſt, diſcharge a kind of froth or ſaliva from the anus and pores of the body, under which they conceal themſelves from the rapacity of birds and other enemies.—The *papa*, or water ſcorpion, frequents ſtagnant waters. It lives chiefly on aquatic inſects, and is exceedingly voracious.—Many ſpecies of the *cimex*, or bug, feed upon the juices of plants, and others upon the blood of animals. Some of them are found in waters, and others frequent houſes, among which, though it wants wings, is the bed-bug, a peſtiferous inſect, which is too well known, and too generally diffuſed. The bugs differ from other inſects by their ſoftneſs; and moſt of them emit a very fetid ſmell.—The inſect called

aphis, or tree-louſe, is very common. There are a great many ſpecies, denominated from the trees and plants which they infeſt: they are viviparous in ſummer, and oviparous in autumn. Numbers of thoſe called vine-fretters are devoured by the ants, on account, it is ſuppoſed, of a ſweet liquor with which their bodies are perpetually moiſtened. The caterpillars of the *chermes*, have ſix feet, and are generally covered with a hairy or woolly ſubſtance. The winged inſects leap or ſpring with great agility, and infeſt a number of different trees and plants: the females, by means of a tube at the termination of their bodies, inſert their eggs under the ſurface of the leaves, and the worms, when hatched, give riſe to thoſe tubercles, or galls, with which the leaves of the aſh, the fir, and other trees, are ſometimes almoſt entirely covered.—I ſhall proceed further in this ſubject, and finiſh the remaining orders of the inſect tribes in my next paper.

XXXIV. A VIEW OF THE INSECT TRIBES, CONTINUED.

What atom-forms of inſect life appear!
And who can follow nature's pencil here?
Their wings with azure, green, and purple gloſs'd,
Studded with colour'd eyes, with gems emboſs'd,
Inlaid with pearl, and mark'd with various ſtains
Of lively crimſon thro' their duſky veins.

BARBAULD.

LINNE's third order of inſects, termed *lepidoptera*, has four wings, and conſiſts of three genera only; but the ſpecies comprehended under them are

exceedingly numerous. All butterflies and moths belong to this order. Their wings are covered with a farinaceous powder, or rather with a kind of ſcales or feathers, diſpoſed in regular rows, nearly in the ſame manner as tiles are laid upon the roofs of houſes. The elegance, the beauty, the variety of colours exhibited in their wings are produced by the diſpoſition and different tinctures of theſe minute feathers. The inſects of this order, on account of their beauty and eaſy preſervation, have always been the favourites of collectors, and particularly of thoſe of the female ſex. When the feathers are rubbed off, the wings appear to be nothing more than a naked, and often a tranſparent membrane. The feelers of the papilio, or butterfly, are thickeſt at their extremity, and often terminate in a kind of knob, or head. Their wings, when ſitting, or at reſt, are erect, their extremities join each other above the body, and the animals fly about, in queſt of food and of their mates, during the day.—The moths are divided into two genera, the one called *ſphinx*, or hawk-moth, and the other *phalaena*, or moth. The feelers of the *ſphinx* are thicker in the middle than at the extremities, and their form, in ſome meaſure reſembles that of a priſm. The wings are, in general, deflected, their outer margins declining toward the ſides. They fly about early in the morning, and after ſunſet; and, by means of their proboſcis, like the butterflies, they ſuck the juices of plants.—The feelers of the *phalaena* are ſetaceous, and taper from the baſe to the point. When at reſt, their wings are commonly deflected; and they fly during the night. Previous to their transformation, the caterpillars of the whole of this genus ſpin webs for covering and protecting the animals while in the chryſalis ſtate. From a ſpecies of this tribe mankind have derived one of the greateſt articles of luxury and of commerce which now exiſts

in the world. That ſeemingly contemptible, and diſguſting reptile the ſilkworm, in its paſſage from the caterpillar to the chryſalis ſtate, produces thoſe ſplendid materials which adorn the thrones of princes, and add dignity and luſtre to female beauty.

The fourth order of inſects is diſtinguiſhed by the name of *neuroptera*. They have four wings, which are membranaceous, naked, and ſo interſperſed with delicate veins, that they have the appearance of beautiful network. Their tail has no ſting; but that of the male is frequently furniſhed with a kind of forceps or pincers. To this order belongs the *libella*, or dragon-fly, an inſect of very ſplendid and variegated colours. It is a large and well known fly, and frequents rivers, lakes, pools, and ſtagnating waters, in which the females depoſit their eggs. Under the ſame order is comprehended the *phryganea*, or ſpring-fly: the caterpillars of this genus live in the water, and are covered with a ſilken tube. They have a very ſingular aſpect; for, by means of a gluten, they attach to the tubes in which they are incloſed ſmall pieces of wood, ſand, gravel, leaves of plants, and not unfrequently live on teſtaceous animals, all of which they drag along with them. They are very commonly found in ſalads of the water-creſs; and, as they are often entirely covered with green leaves, they have the appearance of animated plants. They are in great requeſt among fiſhermen, by whom they are diſtinguiſhed by the name of ſtone or cod-bait. The fly, or perfect inſect, frequents running waters, in which the females depoſit their eggs.

The fifth order is termed *hymenoptera*. In general, the inſects belonging to this order have four membranaceous and naked wings. In ſome of the genera, however, the neuters, and, in others, the males, or even, the females, have no wings. Their tails, except in the male ſex, are armed with a ſting.

The female of the *cynips*, an inſect belonging to this order, inſerts her eggs into the leaves of the oak, and the caterpillars produced from them give riſe to the galls employed in the compoſition of ink.—This order likewiſe includes the waſp, the bee, and the ant. Many of the waſp kind, like the bees, live in ſociety, make combs in which the females depoſit their eggs, and feed their caterpillars with an inferior ſpecies of honey. Others of them conſtruct a ſeparate neſt for each individual egg.—The bee is an inſect too well known to require a particular deſcription. The males have no ſting; but the females, and the drones, or neuters, have a very ſharp pointed ſting concealed in their abdomen. The female of the honey bee is much larger than the male, or the neuter; her feelers contain fifteen articulations; and her abdomen, compoſed of ſeven ſegments, is much longer than her wings. The feelers of the male contain only eleven articulations. The neuters are much ſmaller than the males or females, and their feelers conſiſt of fifteen articulations.—The male and female ants are armed with a ſting, which is concealed within the abdomen. The males and females are furniſhed with wings, but the neuters are deprived of theſe inſtruments of motion. The ants live in ſocieties which are compoſed of males, females, and neuters: the males are much ſmaller than the females and neuters. Soon after the males and females propagate the ſpecies, they all die: ſome of the neuters, however, ſurvive the winter; but they remain in their habitation without movement, or diſcovering any ſigns of life. From theſe circumſtances in the hiſtory of ants, it is apparent, that the induſtry and ſagacity ſo long and ſo univerſally aſcribed to theſe little animals could be of no uſe either to themſelves or their progeny. The females, after depoſiting their eggs, take no further care of their offſpring. But, what is ſingular,

the important office of feeding the caterpillars, after the eggs are hatched, is left entirely to the neuters. This affectionate and aſſiduous attention of the neuters to a progeny neither begot nor brought forth by them, is ſo aſtoniſhing, ſo contrary to the general economy of Nature, that no reaſoning or theory can account for a fact ſo uncommon, till further diſcoveries ſhall be made in the hiſtory of theſe ſurpriſing animals. What is ſtill more ſingular, after the caterpillars are transformed into the chryſalis ſtate, the neuters are inceſſantly and anxiouſly employed in preſerving the chryſalis from humidity when the weather is wet, and in expoſing them to the warmth of the ſun when it is fair. Theſe chryſaliſes are larger than the animals themſelves, and yet they carry them off with eaſe and rapidity.

The ſixth order of inſects is termed *diptera*, or two-winged inſects. The different ſpecies of this order, beſide wings, are furniſhed with what is called a halter, or a poiſer, which is ſituate under each wing, and is terminated by a knob. This order comprehends ten genera and a multitude of ſpecies. The caterpillars of the *æſtrus*, or gadfly, lie concealed in the ſkins of cattle, where they are nouriſhed during the whole winter. The perfect inſects are frequent wherever horſes, cows, or ſheep, are grazing. Some of them depoſit their eggs in the ſkins of cows or oxen; others depoſit them in the inteſtines of horſes, to which they get acceſs by the anus; and others in the noſtrils of ſheep. In theſe habitations, the caterpillars reſide till they are full grown, when they throw themſelves down to the earth, and generally paſs the cryſalis ſtate under the firſt ſtone they meet with.—The mouth of the *muſca*, or common fly, conſiſts of a ſoft, fleſhy proboſcis, with two latteral lips. The caterpillars of ſome of this genus devour the pucerons; others conſume all kinds of putrid fleſh; others are found in cheeſe;

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others in the excrements of different animals; and many of them live in the water, and prefer that which is moſt corrupted and muddy.—The mouth of the *culex*, or gnat, conſiſts of a flexible ſheath, incloſing four briſtles, or pointed ſtings. The feelers of the female gnat are plain like a thread; but thoſe of the male are beautifully feathered. The caterpillars of this genus are commonly found in ſtagnant waters. The gnats generally frequent woods and marſhy places. The females, in particular, are very troubleſome, and ſting ſeverely.—The feet of the *hippoboſca*, or horſefly, are armed with a number of nails or crotchets: in ſome ſpecies, the wings croſs each other; in others, they are open. The horſeflies frequent woods and marſhy grounds, and are extremely incommodious to birds and quadrupeds, whoſe blood is the only food of theſe inſects.

The ſeventh, and laſt order of inſects Linné denominates *aptera*, becauſe neither males nor females are furniſhed with wings. This order comprehends thirteen genera, and a great number of ſpecies, many of which are very offenſive and noxious to the human ſpecies. The *pediculus*, or louſe, has ſix legs, two prominent eyes, and its mouth contains a ſting or ſucker, by which it extracts blood and other juices from the bodies of animals. Though almoſt every different animal is infeſted with a peculiar ſpecies of lice, the ſpecific characters of very few of them have hitherto been aſcertained. Lice are of various forms; ſome of them oval, others oblong, and others long and ſlender. They are oviparous animals, and their eggs are large in proportion to the ſize of their bodies. Before they arrive at maturity, they change their ſkin ſeveral times.—The *pulex*, or flea, has likewiſe ſix legs, the articulations of which are ſo exceedingly elaſtic, that the animal is enabled by their means, to ſpring to a ſurpriſing diſtance. It has two fine eyes, and its body is co-

vered with cruſtaceous ſcales. The flea is the only inſect belonging to this order which undergoes a transformation ſimilar to that of the former orders: all the other wingleſs inſects are produced in a perfect ſtate, either by the mother or from eggs. The caterpillars of the flea have forked tails, and are very ſmall and lively. They may be nouriſhed in boxes, and fed with flies, which they greedily devour. Before changing into the cryſalis ſtate, they live fourteen or fifteen days in the form of caterpillars.—The genus called *aranea*, or ſpider, comprehends a great many ſpecies. The ſpider has eight feet, and an equal number of immoveable eyes. The chief prey of the ſpider is flies, animals whoſe motions are extremely quick and deſultory. To enable the ſpider to obſerve their movements in every direction, it is furniſhed with eight eyes, the poſition of which merits attention: two of them are placed on the top of the head, other two on the front, and two on each ſide. The mouth is armed with two hooks or fangs, by which it ſeizes and kills its prey. Round the anus there are ſeveral muſcular inſtruments, ſhaped like nipples or teats: each of theſe contain about a thouſand tubes or outlets for threads ſo extremely minute, that many hundreds of them muſt be united before they form one of thoſe viſible ropes of which the ſpiders web is compoſed. The figure of the web varies according to the ſpecies, or the ſituation the animal chooſes for its abode. After the web is completed, ſome ſpecies reſide in the centre, and others occupy the extremity of their habitations, where they lie in ambuſh, with aſtoniſhing patience, till a fly is accidentally entangled. The ſpider, from the vibration of the threads, perceives his prey, ruſhes forth from his cell, inſtantly ſeizes it with his fangs, devours its vitals, and afterward rejects the exhauſted carcaſe. Spiders prey upon all weaker inſects, and even upon their own ſpecies:

But chief to heedleſs flies the window proves
A conſtant death; where, gloomily retir'd,
The villain ſpider lives, cunning, and fierce,
Mixture abhorr'd! Amid a mangled heap
Of carcaſes, in eager watch he ſits,
O'erlooking all his waving ſnares around.
Near the dire cell the dreadleſs wanderer oft
Paſſes, as oft the ruffian ſhows his front:
The prey at laſt enſnar'd, he dreadful darts,
With rapid glide, along the leaning line;
And, fixing in the wretch his cruel fangs,
Strikes backward grimly pleas'd: the fluttering wing
And ſhriller ſound declare extreme diſtreſs,
And aſk the helping hoſpitable hand. THOMSON.

The ſcorpion is a venomous inſect, and a native of warmer climates than thoſe of the north of Europe. It has eight feet, and two claws, the laſt of which are ſituate on the forepart of the head. Like the ſpider, the ſcorpion has eight eyes, three of which are placed on each ſide of the breaſt, and the other two on the back. The tail is long, jointed, and terminates in a ſharp crooked ſting. The venom of the ſcorpion is more deſtructive than that of any other inſect; and is ſometimes fatal in Africa and other hot regions.

Such are the diviſions into which inſects have been claſſed according to the Linnean ſyſtem, and ſuch is their ſtructure and conformation. There are many other curious particulars concerning this wonderful part of the creation, which ſhall be the ſubject of future diſcuſſion. In the mean time, I ſhall conclude this paper, with a beautiful compariſon from the moral Thomſon:

Thick in yon ſtream of light, a thouſand ways,
Upward, and downward, thwarting, and convolv'd,
The quivering nations ſport; till, tempeſt-wing'd,
Fierce Winter ſweeps them from the face of day.
Ev'n ſo luxurious men, unheeding paſs

An idle ſummer life in fortune's ſhine,
A ſeaſon's glitter! Thus they flutter on
From toy to toy, from vanity to vice;
Till, blown away by death, oblivion comes
Behind, and ſtrikes them from the book of life.

XXXV. ON THE TRANSFORMATION OF INSECTS.

Where greatneſs is to Nature's works deny'd,
In art and beauty it is well ſupply'd:
In a ſmall ſpace the more perfection 's ſhown,
And what is exquiſite in little 's done.
'Tis Nature's ſmalleſt products pleaſe the eye,
While greater births paſs unregarded by.
Her monſters ſeem a violence to ſight:
They 're form'd for terror, inſects to delight.
Thus, when ſhe nicely frames a piece of art,
Fine are her ſtrokes, and ſmall in every part.
No labour can ſhe boaſt more wonderful
Than to inform an atom with a ſoul;
To animate her little beauteous fly,
And clothe it in her gaudieſt drapery. YALDEN.

IN my two former papers I took a view of the diviſions into which inſects have been claſſed, according to the Linnean ſyſtem. I am now to give a more particular account of what I have hitherto only incidentally mentioned—the various and wonderful transformations which they undergo.

All winged inſects, without exception, and many of thoſe which are deſtitute of wings, muſt paſs through ſeveral changes before the animals arrive at the perfection of their natures. The appearance, the ſtructure, and the organs of a caterpillar, a chryſalis, and a fly, are ſo different, that, to a perſon unacquainted with their transformations, an identi-

cal animal would be conſidered as three diſtinct ſpecies. Without the aid of experience, who could believe that a butterfly, adorned with four beautiful wings, furniſhed with a long ſpiral proboſcis, inſtead of a mouth, and with ſix legs, proceeded from a diſguſting caterpillar, provided with jaws and teeth, and fourteen feet? Without experience, who could imagine that a long, white, ſmooth, ſoft worm, hid under the earth, ſhould be transformed into a black cruſtaceous beetle, having wings covered with horny caſes?

Beſide their final metamorphoſis into flies, caterpillars undergo ſeveral intermediate changes. All caterpillars caſt or change their ſkins oftener or more ſeldom, according to the ſpecies. The ſilkworm, previous to its chryſalis ſtate, caſts its ſkin four times. The firſt ſkin is caſt on the 10th, 11th, or 12th day, according to the nature of the ſeaſon; the ſecond in five or ſix days after; the third in five or ſix days more; and the fourth and laſt in ſix or ſeven days after the third. This changing of ſkin is not only common to all caterpillars, but to every inſect whatever. Not one of them arrives at perfection without caſting its ſkin at leaſt once or twice. The ſkin, after it is caſt, preſerves ſo entirely the figure of the caterpillar in its head, teeth, legs, colour, hair, &c. that it is often miſtaken for the animal itſelf. A day or two before this change happens, caterpillars take no food; they loſe their former activity, attach themſelves to a particular place, and bend their bodies in various directions, till, at laſt, they eſcape from the old ſkin, and leave it behind them. The inteſtinal canal of caterpillars is compoſed of two principal tubes, the one inſerted into the other: the external tube is compact and fleſhy; but the internal one is thin and tranſparent. Some days before caterpillars change into the chryſalis ſtate, they void, along with their excrement, the

inner tube which lined their ſtomach and inteſtines. When about to paſs into the chryſalis ſtate, which is a ſtate of imbecility, they ſelect the moſt proper places and modes of concealing themſelves from their enemies. Some, as the ſilkworm and many others, ſpin ſilken webs or cords round their bodies, which completely diſguiſe the animal form. Others leave the plants upon which they formerly fed, and hide themſelves in little cells which they make in the earth. The rat-tailed worm abandons the water upon the approach of its metamorphoſis, retires under the earth, where it is changed into a chryſalis, and, after a certain time, burſts from its ſeemingly inanimate condition, and appears in the form of a winged inſect. Thus the ſame animals paſs the firſt and longeſt period of their exiſtence in the water, another under the earth, and the third and laſt in the air. Some caterpillars, when about to change into a chryſalis ſtate, cover their bodies with a mixture of earth and of ſilk, and conceal themſelves in the looſe ſoil. Others incruſt themſelves with a ſilky or glutinous matter, which they puſh out from their mouths, without ſpinning it into threads. Others retire into the holes of walls or decayed trees. Others ſuſpend themſelves to the twigs of trees, or to other elevated bodies, with their heads undermoſt. Some attach themſelves to walls, with their heads higher than their bodies, but in various inclinations: and others chooſe a horizontal poſition. Some fix themſelves by a gluten, and ſpin a rope round their middle to prevent them from falling. Thoſe which feed upon trees attach themſelves to the branches, inſtead of the leaves, which are leſs durable, and ſubject to a greater variety of accidents. The colours of the caterpillars give no idea of thoſe of the future flies.

In general, the figure of chryſaliſes approaches to that of a cone, eſpecially in their poſterior part.

When under this form, the inſect ſeems to have neither legs nor wings. It is incapable either of walking or of crawling. It takes no nouriſhment, becauſe it has no organs ſuited to that purpoſe; yet, in ſome ſpecies, life is continued for ſeveral months before their laſt metamorphoſis takes place. In a word, it ſeems to be a lifeleſs maſs. But, upon a more attentive obſervation, it poſſeſſes the power of bending upward and downward the poſterior part of its body. The ſkin, or exterior covering, of thoſe which do not ſpin cods, ſeems to be of a cartilaginous nature. It is commonly ſmooth and ſhining; but in ſome ſpecies it is more or leſs covered with hair, and other rugoſities. Though chryſaliſes differ both in figure and colour, their appearances are by no means ſo various as thoſe of the caterpillars from which they are produced. The colour of ſome chryſaliſes is that of pure gold, from which circumſtance the whole have received their denomination. For the ſame reaſon they are called *aureliæ* in Latin. Some are brown, others green; and, indeed, they are to be found of almoſt every colour and ſhade.

The life of winged inſects conſiſts of three principal periods, which preſent very different ſcenes to the ſtudent of Nature. In the firſt period, the inſect appears under the form of a worm or caterpillar. Its body is long, cylindrical, and conſiſts of a ſucceſſion of rings, which are generally membraneous, and encaſed within each other. By the aid of its rings, or of crotchets, or of ſeveral pairs of legs, it crawls about in queſt of food; and its movements are, in ſome ſpecies, remarkably quick. Its head is armed with teeth, or pincers, by which it eats the leaves of plants or other kinds of food. In this ſtate, it is abſolutely deprived of ſex, and, conſequently, of the power of multiplication. Its blood moves from the tail toward the head. It reſpires either by ſmall apertures placed on each ſide of its body, or

by one or ſeveral tubes ſituate on its poſterior part, which have the reſemblance of ſo many tails. In the ſecond period, the inſect appears under the form of a nymph, or that of a chryſalis. When an inſect, after throwing off the ſkin of the caterpillar, exhibits all its external parts, only covered with ſoft and tranſparent membranes, it is called a nymph: but, when to theſe membranes is added a common and cruſtaceous covering, it receives the name of a chryſalis. While in the ſtate of a nymph, or a chryſalis, inſects, in general, are totally inactive, and ſeem not to poſſeſs any powers of life. They can make no uſe of their eyes, their mouth, or any of their members; for they are all impriſoned by coverings more or leſs ſtrong. Deprived of the faculty of motion, they remain fixed in thoſe ſituations which they have choſen for their temporary abode, or where chance has placed them, till their final metamorphoſis into flies. Some of them, however, are capable of changing place; but their movements are ſlow and painful. Their blood circulates, but in a contrary direction from what takes place in the caterpillar ſtate; for it proceeds from the head toward the tail. Reſpiration continues to go on, but the organs are differently ſituate. In the caterpillar, the principal organs of reſpiration were placed at the poſterior part of the body; but now theſe ſame organs are to be found at the anterior part of the animal. In the third period, the inſect has acquired that perfect organization which correſponds to the rank it is to hold in the ſcale of animation. The bonds of the nymph, or the chryſalis, are now burſt aſunder, and the inſect commences a new mode of exiſtence. All its members, formerly ſoft, inactive, and folded up in an envelope, are expanded, ſtrengthened, and expoſed to obſervation. Under the form of a worm or caterpillar, it crawled; under that of a nymph, or chryſalis, its power of motion was almoſt annihi-

lated; under the laſt form, it is furniſhed with ſix ſpringy legs, and two or four wings with which it is enabled to fly through the air. Inſtead of teeth or pincers, with which it divided a groſs aliment, it has now a trunk by which it extracts the refined juices of the moſt delicate flowers. Inſtead of a few ſmooth eyes which it poſſeſſed in the worm or caterpillar ſtate, the new inſect is furniſhed with both ſmooth and convex eyes, to the number of ſeveral thouſands.

The internal parts of the inſect have likewiſe undergone as many changes as the external. The texture, the proportions, and the number of the viſcera, are greatly altered. Some have acquired an additional degree of conſiſtence; others, on the contrary, are rendered finer and more delicate. Some receive a new form, and others are entirely annihilated. Laſtly, ſome organs in the perfect inſect, which ſeemed formerly to have no exiſtence, are unfolded, and become viſible. The moſt important of this laſt kind are the organs of generation. The caterpillar, the nymph, and the chryſalis, were of no ſex; but, after transformation, both ſexes are diſtinguiſhable, and the animals are capable of multiplying their ſpecies.

But there are ſome examples of transformations which deviate from the common mode. Some inſects hold a middle rank between thoſe which preſerve their original figure during life, and thoſe that ſuffer transformations. Their exiſtence is divided into two periods only: they walk in the firſt, and fly in the ſecond. Thus their only metamorphoſis conſiſts of the addition of wings, the growth and expanſion of which are performed without any conſiderable alteration in the figure of their bodies.

There is not a law eſtabliſhed among organized bodies which ſeems to be ſo univerſal, as that all of them grow, or augment in ſize, after birth, till they

arrive at maturity. If a hen was to bring forth an egg as large as her own body, and if this egg, when hatched, was to produce a bird of equal dimenſions with either of the parents, it would be conſidered as a miracle. But the ſpider-fly, ſo denominated from its figure, affords an example of a ſimilar prodigy. This fly actually lays an egg, from which a new fly is hatched that is as large and as perfect as its mother. This egg is roundiſh, is at firſt white, and afterward aſſumes a ſhining black colour. Upon a more accurate examination, however, this production was found to be an egg only in appearance. When the envelope is removed, inſtead of a gelatinous ſubſtance, the new inſect, furniſhed with all its members, is diſcovered. But this diſcovery does not render the fact the leſs wonderful. All winged inſects undergo their different transformations after being expelled from the bodies of their mothers, and receive great augmentations of ſize before their metamorphoſis into the nymph or chryſalis ſtate, after which their growth ſtops. But the ſpider-fly affords an inſtance of an inſect transformed in the belly of its mother, and which grows no more after it eſcapes from its envelope. The fact is fully authenticated by Reaumur, Bonnet, and other naturaliſts.

The worm from which the *tipula*, or crane-fly, is produced, is perfectly ſmooth. Immediately before its firſt transformation it retires under ground. After this metamorphoſis, the ſurface of the nymph is furniſhed with a number of prickles. By means of theſe prickles, the nymph, when about to be tranſformed into a fly, raiſes itſelf in its hole till the cheſt of the inſect is above ground. The fly then burſts its priſon, mounts into the air, and leaves its former covering behind in the earth.

Many ſpecies of flies depoſit their eggs in the leaves and different parts of plants. Soon after the egg is inſerted into the leaf, a ſmall tubercle begins to appear, which gradually increaſes in magnitude

till the animal is hatched, and has paſſed through its different transformations. Theſe tubercles are known by the name of galls, and are very different in their form, texture, colour, and ſize. Galls of every kind, however, derive their origin from the ſtings of inſects, which generally belong to the claſs of flies. The female fly, by means of her ſting, makes inciſions in the leaves or branches of a tree, and in each inciſion ſhe lays an egg. This egg is at firſt extremely minute; but it ſoon acquires a conſiderable bulk, and the gall has arrived at its full ſize before the worm is hatched. This gall ſeems to be analogous to the membranes which inveſt a fetus, and expands in all directions in proportion to its growth. That the eggs of oviparous animals grow while in the ovarium is univerſally known; but it is ſingular that the eggs of gall-flies ſhould grow after being ſeparated from the body of the mother. Theſe eggs muſt undoubtedly be furniſhed with external veſſels, or a kind of roots, by which they extract juices from the internal cavity of the gall. Malphigius aſcribes the origin of galls to a corroſive liquor introduced by the fly into the wound. But Reaumur, to account for the growth of a gall, thinks it unneceſſary to have recourſe to any ſuppoſed poiſonous fluids, and attributes it to the ſuperabundant nutritious juices derived to that particular part by the continual action of the abſorbent veſſels of the egg, joined to its heat, which may be compared to a little fire placed in the centre of the tumour.

I ſhall not inquire whether theſe cauſes are ſufficient to explain the growth of galls. But, that the eggs depoſited by the flies augment in ſize; that worms proceed from them; that theſe worms are nouriſhed, and live a certain time impriſoned in the galls; that they are there transformed into nymphs or chryſaliſes; and, laſtly, that they are metamorphoſed into winged inſects, which, by gnawing an aperture through the gall, take their flight in the air; are

known and inconteſtible facts. Examine the common oak-galls, or thoſe of any other tree; if any of them happen to have no aperture, cut them gently open, and you are certain to find an egg, a worm, a chryſalis, or a fly; but in ſuch as are perforated, not a veſtige of an animal is diſcoverable.

Some caterpillars, when about to transform, make a belt paſs round their bodies. This belt is compoſed of an aſſemblage of ſilken threads ſpun by themſelves, the ends of which they paſte to the twigs of buſhes, or other places where they chooſe to attach their bodies. They likewiſe fix their hind legs in a tuft of ſilk. After transformation, the chryſaliſes remain fixed in the ſame manner as before their metamorphoſis. The belt is looſe, and allows the chryſalis to perform its ſlow and feeble movements.

The whole moth-kind, as well as the ſilkworm, immediately before their tranſformation into the chryſalis ſtate, cover their bodies with a cod or clue of ſilk, though the nature of the ſilk, and their mode of ſpinning, are very different. The cod of the ſilkworm is compoſed of pure ſilk, and produced by numberleſs circumvolutions and zigzags of the ſame thread. Their figure is generally oval, which neceſſarily reſults from that of the animal's body upon which they are moulded. When ſpinning, they twiſt their bodies into the form of an S. The ſilk is ſpun by an inſtrument ſituate near the mouth of the inſect. The ſilky matter, before it is manufactured by the ſpinning inſtrument, appears under the form of a gum almoſt liquid, which is contained in two large reſervoirs contorted like the inteſtines of larger animals, and which terminate at the ſpinning inſtrument by two parallel and ſlender conduits. Each conduit furniſhes matter for one thread. The ſpinning inſtrument, as is evident when viewed by the microſcope, unites the two threads into one. Thus a thread of ſilk, which has the appearance of being ſingle, is in reality double, and ſpun with

great dexterity. Some writers, who delight in the marvellous, aſcribe foreſight to the ſilkworm in ſpinning its cod. The ſilkworm, it muſt be acknowledged, acts as if it foreſaw the approaching event. But the truth is, that, when the animal has acquired its full growth, its reſervoirs of ſilk are completely filled. It then ſeems to be ſtrongly ſtimulated to evacuate this glutinous matter. Its different movements and attitudes, while diſcharging the ſilk, produce thoſe oval bundles which clothe and ornament vaſt numbers of the human ſpecies.

Another ſpecies of caterpillar conſtructs its cod in the form of a boat with the keel uppermoſt; but it conſiſts not entirely of pure ſilk. The animal, with its teeth, detaches ſmall triangular pieces of bark from a buſh or a tree. Theſe pieces of bark it paſtes upon its body by means of a glutinous or ſilky ſubſtance, and they conſtitute a principal part of its cod.

Another ſpecies works alſo in wood, though not with equal art as the former. Its cod is compoſed entirely of ſmall irregular fragments of dried wood. Theſe fragments the animal has the addreſs to unite together, and to form of them a kind of box which covers and defends its whole body. It accompliſhes this purpoſe by moiſtening, for ſome moments, the pieces of wood in its mouth, and then attaches them to each other by a glutinous ſubſtance. Of this mixture the caterpillar forms a cod, the ſolidity of which is nearly equal to that of wood.

The moſt ſolitary of all inſects are thoſe which live in the internal parts of fruits. Many of them undergo their metamorphoſis in the fruit itſelf, which affords them both nouriſhment and a ſafe retreat. They dig cavities in the fruit, which ſome of them either line with ſilk, or ſpin cods. Others leave the fruit, and retire to be transformed in the earth.

The metamorphoſis of inſects has been regarded as a ſudden operation, becauſe they often burſt their

ſhell or ſilky covering quickly, and immediately appear furniſhed with wings. But, by more attentive obſervation, it has been diſcovered that the transformation of caterpillars is a gradual proceſs from the moment the animals are hatched till they arrive at a ſtate of perfection. Why, it may be aſked, do caterpillars ſo frequently caſt their ſkins? The new ſkin, and other organs, were lodged under the old ones, as in ſo many tubes or caſes, and the animal retires from theſe caſes, becauſe they have become too ſtrait. The reality of theſe encaſements has been demonſtrated by a ſimple experiment. When about to molt or caſt its ſkin, if the foremoſt legs of a caterpillar are cut off, the animal comes out of the old ſkin deprived of theſe legs. From this fact, Reaumur conjectured, that the chryſalis might be thus encaſed, and concealed under the laſt ſkin of the caterpillar. He diſcovered that the chryſalis, or rather the butterfly itſelf, was incloſed in the body of the caterpillar. The proboſcis, the antennæ, the limbs, and the wings of the fly are ſo nicely folded up, that they occupy a ſmall ſpace only under the firſt two rings of the caterpillar. In the firſt ſix limbs of the caterpillar are encaſed the ſix limbs of the butterfly. Even the eggs of the butterfly have been diſcovered in the caterpillar long before its transformation.

From theſe facts it appears, that the transformation of inſects is only the throwing off external and temporary coverings, and not an alteration of the original form. Caterpillars may be conſidered as analogous to the fetuſes of men and of quadrupeds. They live and receive nouriſhment in envelopes till they acquire ſuch a degree of perfection as enables them to ſupport the ſituation to which they are ultimately deſtined by Nature.

XXXVI. ON TRANSFORMATION IN GENERAL.

Omnia transformant ſeſe in miracula rerum.

VIRGIL.

From form to form they paſs in wondrous change.

THE transformation of caterpillars into winged inſects has long excited our admiration. But tranſformation is not confined to them: all animals, without exception, undergo changes in their ſtructure, mode of exiſtence, and external appearances. Mankind, from their embryo ſtate to their final diſſolution, aſſume many different forms. With reſpect to an infant, immediately after birth, it is obſervable to all, that its form, its ſymmetry, and its organs, are by no means complete. The head, for ſome time, is diſproportionally large; the hands and feet are not properly ſhaped; the hair is ſhort and ſcanty; and no teeth appear. In a few months, however the ſymmetry of all the parts is evidently improved, and the teeth begin to ſhoot. The growth of the whole body, and the ſtrength and beauty of its form, gradually advance to perfection till the ſixth or ſeventh year, when another change takes place. At this period, the firſt ſet of teeth are ſhed, and are replaced by knew ones. From boyhood to puberty, the ſize of the body, and of its different members, increaſes. When the age of puberty arrives, ſeveral important changes are produced. From this period, to the age of twenty-five or thirty, the muſcles ſwell, their interſtices are filled with fat, the parts bear a proper proportion to each other, and man may now be conſidered as a perfect animal. In this ſtate of perfection and vigour, he generally remains till he reaches his fiftieth year. Then a new, but a gra-

dual change, begins to appear. From the fiftieth year to the age of ſeventy or eighty, the powers of the body decline in ſtrength and activity. The muſcles loſe their ſpring and their force; the vigour of manhood is no longer felt; and the decrepitude of old age is ſucceeded by death, its unavoidable conſequence.

The mind of man undergoes changes as well as his body. The taſte, appetites, and diſpoſitions, are in perpetual fluctuation. How different is the taſte of a child from that of a man! Fond of gewgaws and of trifling amuſements, children frolic away their time without much reflection. When advancing toward puberty, their diſpoſitions and deſires ſuffer a gradual mutation. New inſtincts are unfolded, and a ſenſe of propriety begins to be perceived. They deſpiſe their former occupations and amuſements; and different ſpecies of objects ſollicit and obtain their attention. Their powers of reflection are now conſiderably augmented; and both ſexes acquire a modeſty and a ſhyneſs with regard to each other. This awkward, but natural baſhfulneſs, by the intercourſe of ſociety, as well as by the impulſes of Nature, vaniſhes ſoon after puberty, when the ſtate of manhood commences. From this period, to the age of twenty-five or thirty, men's minds aſſume a bold, enterpriſing, and active tone. They engage in the buſineſs of life, look forward to futurity, and have a deſire of marrying, and of eſtabliſhing families. All the ſocial appetites are in vigour; ſolid and manly friendſhips are formed; and man goes on for ſome time to enjoy every kind of happineſs which his nature is capable of affording. At fifty or ſixty, the mental powers, in general, like thoſe of the body, begin to decline, till feeble old age arrives, and death terminates the ſcene.

With regard to quadrupeds, both before and af-

ter birth, they undergo ſimilar, and many of them greater changes of form than thoſe of the human ſpecies. Their mental powers, likewiſe, their diſpoſitions and manners, as well as the objects of their attention, vary according to the different ſtages of their exiſtence. Many of them come into the world blind, and continue for ſome time before they receive the ſenſe of ſeeing. How many changes are exhibited in the dog from birth till he becomes a perfect animal, till all his members are completely formed, and all his inſtincts are unfolded and improved by experience and education! The deer-kind acquire not their magnificent and beautiful horns before the age of puberty; and even theſe are annually caſt off and renewed. Similar changes take place in quadrupeds of every denomination.

Many birds, like quadrupeds, are blind for ſome time after they are hatched. In this condition, how different are their form and appearances from thoſe of the perfect animals! At firſt, they are covered with a kind of down inſtead of feathers. Even after the feathers ſhoot, they are often of a colour different from that which they acquire when full grown. The beautiful variegated colours of the peacock's tail appear not till he arrives at his third year. Birds that have creſts, live a conſiderable time before they acquire theſe ornaments. All birds annually moult, or caſt their feathers, in the ſame manner as quadrupeds ſhed their hair.

Frogs, and many other amphibious animals, undergo great changes in their form and ſtructure. When it firſt eſcapes from the egg, a frog appears in the form of a tadpole, an animal with a large roundiſh head, and a compreſſed or flat tail, but deſtitute of feet and legs. In this ſtate it remains a conſiderable time, when the two fore-feet begin to ſhoot, and have an exact reſemblance to the buds of trees. As their growth advances, the toes and legs

are diſtinguiſhable. The ſame proceſs goes on with the hind legs, but they are ſomewhat later in making their appearance. During the growth of the legs, the blood being drawn into different channels, the tail ſuffers a gradual mortification, till at laſt it vaniſhes, and the tadpole is metamorphoſed into a quadruped. Tadpoles never come out of the water; but, after their transformation into frogs, they become amphibious, and occaſionally frequent both land and water.

The cruſtaceous tribes, as lobſters, crabs, &c. beſide the different appearances they aſſume while growing to perfection, caſt their ſhells every year. When this change is about to happen, they retire into the crevices of rocks, or ſhelter themſelves below detached ſtones, with a view to conceal and defend their bodies from the rapacious attacks of other fiſhes. After the ſhells are caſt, the animals are exceedingly weak and defenceleſs. Inſtead of their natural defence of hard ſhells and ſtrong claws, they are covered only with a thin membrane or ſkin. In this ſtate they become an eaſy prey to almoſt every fiſh that ſwims. The ſkin, however, gradually thickens and grows harder, till it acquires the uſual degree of firmneſs. By this time the animals have reſumed their former ſtrength and activity; they come out from their retreats, and go in queſt of food.

Serpents, and many other reptiles, caſt their ſkins annually. The beauty and luſtre of their colours are then highly augmented. Before caſting, the old ſkins have a tarniſhed and withered appearance. The old ſkins, like the firſt ſet of teeth in children, are forced off by the growth of the new.

But transformations are not peculiar to animals. All organized bodies paſs through ſucceſſive changes. Plants, of courſe, are not exempted from mutation. What an amazing difference between an acorn and a ſtately oak! The ſeeds of plants may be com-

pared to the chryſaliſes of butterflies. The ſeed, like the chryſalis, contains, in miniature, all the parts of the future plant. These parts require only time, and other circumſtances neceſſary to vegetation, for their complete evolution. How different are the ſeed-leaves from thoſe of the plume! Beſide the general changes ariſing from growth, plants undergo a number of metamorphoſes from other cauſes. In northern climates, if we except a few evergreens, trees, during winter, are entirely ſtripped of their leaves. Inſtead of the pleaſant emotions excited by the variety of figures, movements, colours, and fragrance of the leaves, flowers, and fruit, during the ſpring and ſummer, nothing is exhibited in winter but the bare ſtems and branches. In this ſtate, the trees of the foreſt have a lugubrious appearance. Very different are the emotions we feel in ſpring, when the buds begin to burſt, and the leaves to expand. When ſummer approaches, another beautiful change takes place. The flowers, with all their ſplendour of colours, and ſweetneſs of ſcents, are then highly delightful to our ſenſes. After performing the office of cheriſhing and protecting the tender fruit for ſome time, the flowers drop off, and a new change is exhibited. When the flowers fall, the young fruit appear, and gradually grow to maturity, perpetually preſenting varieties in their magnitude, colour, odour, and flavour. When the fruit and ſeed are fully ripe, they are gathered for the uſe of man, drop down upon the earth, or are devoured by birds and other animals. After this change happens, to which all the others were only preparatory, the leaves begin to ſhed, winter commences, and the ſame ſeries of metamorphoſes goes on during the exiſtence of the plant.

The changes juſt now mentioned are annual, and are ultimately intended to ſupply men and other animals with food. But plants are ſubjected to changes

of form from cauſes of a more accidental nature. Varieties or changes in the figure of plants are often produced by ſoil, by ſituation, by culture, and by climate.

Thus it appears, that, in both the animal and vegetable kingdoms, forms are perpetually changing. The mineral kingdom is not leſs ſubject to metamorphoſes. But though forms continually change, the quantity of matter is invariable. The ſame ſubſtances paſs ſucceſſively into the three kingdoms, and conſtitute in their turn, a mineral, a plant, an inſect, a reptile, a fiſh, a bird, a quadruped, a man. In theſe transformations, organized bodies are principal agents. They change or decompoſe every ſubſtance that either enters into them, or is expoſed to the action of their powers. Some they aſſimilate, by the proceſs of nutrition, into their own ſubſtance; others they evacuate in different forms; and theſe evacuations make ingredients in the compoſitions of other bodies, as thoſe of inſects, whoſe multiplication is prodigious, and affords a very great quantity of organized matter for the nouriſhment and ſupport of almoſt every animated being. Thus, from the apparent vileſt and moſt contemptible ſpecies of matter, the richeſt productions derive their origin. The moſt beautiful flowers, the moſt exquiſite fruits, and the moſt uſeful grain, all proceed from the boſom of corruption. The earth is continually beſtowing freſh gifts upon us; and her powers would ſoon be exhauſted, if what ſhe perpetually gives were not perpetually reſtored to her. It is a law of Nature, that all organized bodies ſhould be decompoſed, and gradually transformed into earth. While undergoing this ſpecies of diſſolution, their more volatile particles paſs into the air, and are diffuſed through the atmoſphere. Thus animals, at leaſt portions of them, are buried in the air, as well as in the earth, or in water. Theſe

floating particles ſoon enter into the compoſition of new organized beings, who are themſelves deſtined to undergo the ſame revolutions. This circulation of organized matter has continued ſince the commencement of the world, and will proceed in the ſame courſe till its final deſtruction.

With regard to the intentions of Nature in changing forms, a complete inveſtigation of them exceeds the powers of human reſearch. One great intention, from the examples above enumerated, cannot eſcape obſervation. In the animal world, every ſucceſſive change is a new approach to the perfection of the individuals. Men, and the larger animals, ſome time after the age of puberty, remain ſtationary, and continue to multiply their ſpecies for periods proportioned to their reſpective ſpecies. When thoſe periods terminate, they gradually decay till their final diſſolution. The ſame obſervation is applicable to the inſect tribes, whoſe transformations ſtrike us with wonder. The caterpillar repeatedly moults or caſts off its ſkin. The butterfly exiſted originally in the body of the caterpillar; but the organs of the fly were too ſoft, and not ſufficiently unfolded. It remains unfit to encounter the open air, or to perform the functions of a perfect animal, till ſome time after its transformation into a chryſalis. It then burſts through its envelope, arrives at a ſtate of perfection, multiplies its ſpecies, and dies. All the changes in the vegetable kingdom tend to the ſame point. In the proceſs of growing, they are perpetually changing forms till they produce fruit, and then they decay. Some plants, like caterpillars, go through all their transformations, death not excepted, in one year. But others, like man and the larger animals, beſide the common changes produced by growth and the evolution of different organs, continue for many years in a ſtate of perfection before the periods of decay and of diſſolution

arrive. But theſe perennial plants undergo, every year, all the viciſſitudes of the annuals. They every year increaſe in magnitude, ſend forth new leaves and branches, ripen and diſſeminate their ſeeds, and, during winter, remain in a torpid ſtate, or ſuffer a temporary death.

With reſpect to man in particular, it might be inquired, why is he confined to ſo very ſhort a period of exiſtence here, whoſe intellectual attainments ſeem to be too vaſt, his ambition too exalted, to periſh for ever? He undergoes a momentary change; he periſhes for a ſeaſon; to him, who improves his powers, and perſeveres in the paths of piety and virtue, is promiſed another and more glorious tranſformation—a reſurrection to immortal life and everlaſting joy.

I ſhall conclude this paper by obſerving, that to ſome of the preceding obſervations nothing can be more applicable than the awful reflections of Dr. Young:

Lorenzo! ſuch the glories of the world!
What is the world itſelf? *Thy* world—a grave.
Where is the duſt that has not been alive?
The ſpade, the plough, diſturb our anceſtors;
From human mould we reap our daily bread.
The globe around earth's hollow ſurface ſhakes,
And is the ceiling of her ſleeping ſons.
O'er devaſtation we blind revels keep;
Whole bury'd towns ſupport the dancer's heel.
The *moiſt* of human frame the ſun exhales;
Winds ſcatter through the mighty void the *dry*;
Earth repoſſeſſes part of what ſhe gave,
And the freed ſpirit mounts on wings of fire;
Each element partakes our ſcatter'd ſpoils;
As nature, wide, our ruins ſpread: man's death
Inhabits all things, but the thought of man.

XXXVII. ON THE BEAUTY AND VARIETY OF BUTTERFLIES.

Behold! ye pilgrims of this earth, behold!
See all but man with unearn'd pleaſure gay:
See her bright robes the Butterfly unfold,
Broke from her wintry tomb in prime of May!
What youthful bride can equal her array?
Who can with her for eaſy pleaſure vie?
From mead to mead with gentle wing to ſtray,
From flower to flower on balmy gales to fly,
Is all ſhe has to do beneath the radiant ſky.

THOMSON.

AMID the vaſt profuſion of beautiful objects in the creation, no one ſeems more admirably formed to attract the attention of a Contemplative Philoſopher, than the Papilio or Butterfly. The beauty of this inſect, the ſplendour and aſtoniſhing variety of its colours, its elegant form, its ſprightly air, with its roving and fluttering life, all unite to captivate the leaſt obſervant eye. A collection of butterflies, ſuch as that in the Britiſh Muſeum, and at the Leverian Muſeum, is a ſpectacle for the moſt philoſophic mind. Theſe inſects, indeed, ſeem to vie with each other in beauty of tints and elegance of ſhape. The butterflies of China, and particularly thoſe of America, on the river Amazon, are remarkable for their ſize, and for the richneſs and vivid luſtre of their colours. Nor is it too bold an aſſertion, perhaps, that the butterflies of thoſe hot climates afford inſtances of the moſt perfect art of colouring that even Deity itſelf can produce. But no deſcription can be adequate to that, of which the ſight alone can form a competent idea. Hence, in the oriental countries, where the butterfly is ſo much larger and

more beautiful than ours, it is no wonder, that it forms a principal ornament of their poetry.

Nature, in theſe inſects, ſeems to have been fond to ſport in the artificial mixture and diſplay of her moſt radiant treaſures. In ſome, what elaborate harmony of colouring, what brilliancy of tints, what ſoft and gradual tranſitions from one to another! In the wings of others we may obſerve the luſtre and variety of all the colours of gold, and ſilver, and azure, and mother of pearl; the eyes that ſparkle on the peacock's tail; the edges bordered with ſhining ſilks and furbelows, the blended dies of Hungary point, and the magnificence of the richeſt fringe.—In China, the fineſt and moſt extraordinary of theſe inſects are ſent to court, and applied to the decorations of the emperor's palace.

But with whatever admiration we view this beautiful inſect with the naked eye, how greatly is that admiration augmented, when we examine it through the microſcope! Would an uninformed ſpectator ever imagine, that the wings of the butterfly are furniſhed with feathers? And yet this is the opinion of ſome celebrated naturaliſts. That beautiful duſt, ſay they, with which the wings of the butterfly are covered, and to which they owe both their opacity and variegated colouring, is an innumerable cluſter of extremely ſmall feathers, which cannot be diſcovered but by the microſcope. The ſtructure and arrangement of theſe feathers are deſcribed to be as perfect in ſymmetry, as they are beautiful in colouring; the parts which form their centre, and which immediately touch the wing, to be the ſtrongeſt; thoſe, on the contrary, which form the exterior circumference, to be more delicate, and of an extraordinary fineneſs. All theſe feathers, moreover, are ſaid to have a quill at their root; and it is added, that if we ſeize the wing too roughly, we deſtroy the moſt delicate part of the plumage; but that if

we wipe off all that was ſuppoſed to be powder, nothing remains but a fine and tranſparent membrane, where we may eaſily diſcern the little cavities or ſockets, in which the quill of each feather was fixed. This membrane, from the manner in which it is embroidered, is repreſented to be almoſt as eaſily diſtinguiſhed from the reſt of the wing, as fine lace from the cloth upon which it is ſtretched. It is likewiſe ſaid to be more porous and more delicate; to have the appearance of having been wrought by a needle; and to be terminated on the outline by a fringe, the threads of which are infinitely fine, and ſucceed each other with the moſt perfect regularity. —Other naturaliſts, on the contrary, maintain that this ſeeming powder is a profuſion of variouſly-coloured ſcales; but formed, however, in ſuch a manner, as eaſily to deceive the eye by the appearance of feathers. The upper and under parts of the wing are equally furniſhed with theſe, and there is no ſpecies of this inſect, in every wing of which there are not ſeveral figures of theſe feathers or ſcales in ſeveral parts.

In down of ev'ry variegated die
Shines flutt'ring ſoft, the gaudy butterfly:
That powder, which thy ſpoiling hand diſtains,
The form of quills and painted plumes contains;
Not courts can more magnificence expreſs
In all their blaze of gems and pomp of dreſs.

BROWNE.

How much inferior muſt be the moſt magnificent robes, wrought by mortal hands, compared to the beautiful dreſs, with which Nature has inveſted the butterfly. Our richeſt laces are but coarſe cloth, and our fineſt threads but cord, compared to the delicate texture that covers the wings of this inſect. Such is the extreme difference to be obſerved between the works of Nature and theſe of Art, when we contemplate them through a microſcope, that,

while the firſt are finiſhed to our utmoſt ideas of perfection, the latter, and even the moſt admirable of their kind, ſeem to be clumſily performed.—But as this wonderful difference has been noticed in a former paper [a], I need not enlarge on the ſubject here.

What is moſt aſtoniſhing in theſe wonderful inſects is, that yeſterday perhaps, they were produced from an abject and contemptible worm. But now they bear aloft their painted glories,

Of all the varied dies
Their beauty-beaming parent can diſcloſe. THOMSON.

With what vigour do they ſport in the ſolar ray, exult in exiſtence, inhale the odoriferous breeze, and rove in fickle flight from flower to flower.

Their wings (all glorious to behold)
Bedropt with azure, jet, and gold,
Wide they diſplay: the ſpangled dew
Reflects their eyes and various hue. GAY.

How wonderful this transformation from that reptile ſtate, when ſtruggling in the duſt, they were in perpetual danger of being cruſhed by every careleſs foot! And by what omnipotent hand were they enabled thus to riſe from the ground? Who endued them with power to traverſe the aërial plains? Who adorned them with the vivid beauties of their wings? —God, the beneficent creator of the butterfly and of - - - - man: God, who, in this wonderful inſect has preſented us with an image of that transformation which awaits our own periſhable bodies!—Yes, the day will at laſt arrive, when quitting this earthly tabernacle, the good man ſhall no longer creep below. The day will come when "this corruptible muſt put on incorruption, and this mortal muſt put on immortality". The good man then, made perfect and glorified, will ſoar beyond the ſtars, and enjoy unutterable bliſs in ſcenes of everlaſting day.

[a] See No. XXXI.

XXXVIII. ON THE WONDERFUL OPERATIONS OF BEES.

Ac veluti in pratis, ubi apes in æſtate ſerena
Floribus inſidunt varüs, et candida circum
Lilia funduntur— VIRGIL.

To their delicious taſk the fervent bees,
In ſwarming millions tend: around, athwart,
Through the ſoft air, the buſy nations fly,
Cling to the bud, and with inſerted tube,
Suck its pure eſſence, its ethereal ſoul;
And oft, with bolder wing, they ſoaring dare
The purple heath, or where the wild thyme grows,
And yellow load them with the luſcious ſpoil.
THOMSON.

THE wiſdom of Bees, the perfection and harmony of their government, their preſerving induſtry, and wonderful economy, have been celebrated by the natural hiſtorians of every age. Nor has this ſubject been forgotten by the poets. Theſe induſtrious inſects have furniſhed them with ſimilies from the remoteſt times. The great father of poetry compares a crowded hoſt of Greeks to a ſwarm of bees [a]. The Tyrians, employed in building a city, are compared, by Virgil, to bees performing their wonderful operations [b]. My motto, from the ſame author, is part of a ſimile, in which he compares the ghoſts, flitting near the river Lethe, to bees roving in the meeds from flower to flower [c]. But Milton has carried the ſimilitude further than either of his great maſters; for he introduces the conſultation of the fallen angels in Pandemonium, by a deſcription of bees expatiating and conferring their ſtate affairs [d]. Horace, in the fine ode, in which he ſtyles

[a] Iliad ii, 87. [b] Æneid i, 430. [c] Ib. vi, 707.
[d] Paradiſe Loſt i, 768.

Pindar the Theban Swan, modeſtly compares himſelf to a bee, roving with feeble wing and idle murmurs, and with unceaſing labour, culling from each bloom his flowery ſpoils [a]. Lucretius too, while employed in collecting and elucidating the doctrines and leſſons of his maſter Epicurus, compares himſelf to the bee, extracting honey from the moſt fragrant flowers [b]. Shakſpeare exalts the ſubject to far greater conſequence; for he deſcribes the buſy nation as a monarchy:

So work the honey bees;
Creatures, that by a rule in nature teach
The art of order to a peopled kingdom, &c. [c]

Pope has improved this idea:

Learn each ſmall people's genius, policies,
The ant's republic, and the realm of bees;
How thoſe in common all their wealth beſtow,
And anarchy without confuſion know;
And theſe for ever, though a monarch reign,
Their ſeparate cells and properties maintain.
Mark what unvary'd laws preſerve each ſtate,
Laws wiſe as Nature, and as fixt as Fate [d].

And Churchill, after the following beautiful and pictureſque deſcription, introduces a ſovereign, drawing from it, in a ſoliloquy, the moſt natural reflections on the momentous duties of his ſtation:

Strength in her limbs, and on her wings diſpatch,
The bee goes forth; from herb to herb ſhe flies,
From flow'r to flow'r, and loads her lab'ring thighs
With treaſur'd ſweets; robbing thoſe flowers, which left,
Find not themſelves made poorer by the theft,
Their ſcents as lively, and their looks as fair,
As if the pillager had not been there.

[a] Lib. iv. od. 2. [b] Lib. iii. 2. [c] King Henry v. act i. [d] Eſſay on Man, iii, 183.

Ne'er doth ſhe flit on Pleaſure's ſilken wing;
Ne'er doth ſhe, loit'ring, let the bloom of Spring
Unrifled paſs, and on the downy breaſt
Of ſome fair flow'r indulge untimely reſt.
Ne'er doth ſhe, drinking deep of thoſe rich dews
Which Chymiſt Night prepar'd, that faith abuſe
Due to the hive, and, ſelfiſh in her toils,
To her own private uſe convert the ſpoils.
Love of the ſtock firſt call'd her forth to roam,
And to the ſtock ſhe brings her honey home [a].

But more quotations are ſuperfluous: to the poetical part of my ſubject, therefore, I ſhall only add, what every claſſical reader will recollect, that Virgil has devoted the fourth book of his Georgics entirely to the ſubject of bees; a ſubject, which he paints *con amore*, "in all the matchleſs harmony of ſong."

The ſkill and dexterity of the honey-bees, diſplayed in the conſtruction of their combs or neſts, are truly wonderful. They are compoſed of cells regularly applied to each other's ſides. Theſe cells are uniform hexagons or ſix-ſided figures. In a beehive, every part is arranged with ſuch ſymmetry, and ſo finely finiſhed, that, if limited to the ſame materials, the moſt expert workman would find himſelf unqualified to conſtruct a ſimilar habitation, or rather a ſimilar city.

In the formation of their combs, bees ſeem to reſolve a problem which would not be a little puzzling to ſome geometers; namely, A quantity of wax being given, to make of it equal and ſimilar cells of a determined capacity, but of the largeſt ſize in proportion to the quantity of matter employed, and diſpoſed in ſuch a manner as to occupy in the hive the leaſt poſſible ſpace.—Every part of this problem is completely executed by the bees. By applying hexagonal cells to each other's ſides, no void ſpaces are left between them; and, though the ſame end might

[a] Gotham, book iii.

be accompliſhed by other figures, yet they would neceſſarily require a greater quantity of wax. Beſides, hexagonal cells are better fitted to receive the cylindrical bodies of theſe inſects. A comb conſiſts of two rows of cells applied to each other's ends. This arrangement both ſaves room in the hive, and gives a double entry into the cells of which the comb is compoſed. As a further ſaving of wax, and preventing of void ſpaces, the baſes of the cells in one row of a comb ſerve for baſes to the oppoſite row. In a word, the more minutely the conſtruction of theſe cells is examined, the more will the admiration of the obſerver be excited. The walls of the cells are ſo extremely thin, that their mouths would be in danger of ſuffering by the frequent entering and iſſuing of the bees. To prevent this diſaſter, they make a kind of ring round the margin of each cell, and this ring is three or four times thicker than the walls.

It is difficult to perceive, even with the aſſiſtance of glaſs-hives, the manner in which bees operate when conſtructing their cells. They are ſo eager to afford mutual aſſiſtance, and, for this purpoſe, ſo many of them crowd together, and are perpetually ſucceeding each other, that their individual operations can ſeldom be diſtinctly obſerved. It has however, been plainly diſcovered, that their two teeth are the only inſtruments they employ in modelling and poliſhing the wax. With a little patience and attention, we perceive cells juſt begun. We likewiſe remark the quickneſs with which a bee moves its teeth againſt a ſmall portion of the cell. This portion the animal, by repeated ſtrokes on each ſide, ſmooths, renders compact, and reduces to a proper thinneſs of conſiſtence. While ſome of the hive are lengthening their hexagonal tubes, others are laying the foundations of new ones. When a bee puts its head a little way into a cell, we eaſily perceive it

ſcraping the walls with the points of its teeth, in order to detach ſuch uſeleſs and irregular fragments as may have been left in the work. Of theſe fragments the bee forms a ball about the ſize of a pin's head, comes out of the cell, and carries this wax to another part of the work where it is needed. It no ſooner leaves the cell than it is ſucceeded by another bee, which performs the ſame office, and in this manner the work is ſucceſſively carried on till the cell is completely poliſhed.

The cells of bees are deſigned for different purpoſes. Some of them are employed for the accumulation and preſervation of honey. In others, the female depoſits her eggs, and from theſe eggs worms are hatched, which remain in the cells till their final transformation into flies. The drones or males are larger than the common or working bees: and the queen, or mother of the hive, is much larger than either. A cell deſtined for the lodgement of a male or female worm muſt, therefore, be conſiderably larger than the cell of the ſmaller working bees. The number of cells deſtined for the reception of the working bees far exceeds thoſe in which the males are lodged. The honey-cells are always made deeper and more capacious than the others. When the honey collected is ſo abundant that the veſſels cannot contain it, the bees lengthen, and of courſe deepen the honey-cells.

Their mode of working, and the diſpoſition and diviſion of their labour, when put into an empty hive, do much honour to the ſagacity of bees. They immediately begin to lay the foundations of their combs, which they execute with ſurpriſing quickneſs and alacrity. Soon after they begin to conſtruct one comb, they divide it into two or three companies, each of which, in different parts of the hive, is occupied with the ſame operations. By this diviſion of labour, a great number of bees have an opportu-

nity of being employed at the ſame time, and, conſequently, the common work is ſooner finiſhed. The combs are generally arranged in a direction parallel to each other. An interval, or ſtreet, between the combs, is always left, that the bees may have a free paſſage, and an eaſy communication with the different combs in the hive. Theſe ſtreets are wide enough to allow two bees to paſs one another. Beſide theſe parallel ſtreets, to ſhorten their journey when working, they leave ſeveral round croſs paſſages, which are always covered.

With reſpect to the materials employed by bees, it is known that they carry into their hives, by means of their hind thighs, great quantities of the farina or duſt of flowers. After many experiments made by Reaumur, with a view to diſcover whether this duſt contained real wax, he was obliged to acknowledge, that he could never find the wax formed any part of its compoſition. He at length found, by attentive obſervation, that the bees actually eat the farina which they ſo induſtriouſly collect; and that this farina, by an animal proceſs, is converted into wax. This digeſtive proceſs, which is neceſſary to the formation of wax, is carried on in the ſecond ſtomach, and perhaps in the inteſtines of bees. Reaumur likewiſe diſcovered, that all the cells in a hive were not deſtined for the reception of honey, and for depoſiting the eggs of the female, but that ſome of them were employed as receptacles for the farina of flowers, which is the great baſis and raw material of all their curious operations. When a bee comes to the hive with its thighs filled with farina, it is often met near the entrance by ſome of its companions, who firſt take off the load, and then devour the proviſions ſo kindly brought to them. But, when none of the bees employed in the hive are hungry for this ſpecies of food, the carriers of the farina depoſit their loads in cells prepared for

that purpoſe. To theſe cells the bees reſort, when the weather is ſo bad that they cannot venture to go to the fields in queſt of freſh proviſions. As a further evidence that the bees actually eat the farina of flowers, when the ſtomach and inteſtines are laid open, they are often found to be filled with this duſt, the grains of which, when examined by the microſcope, have the exact figure, colour, and conſiſtence of farina, taken from the antheræ of particular flowers. After the farina is digeſted, and converted into wax, the bees poſſeſs the power of bringing it from their ſtomachs to their mouths. The inſtrument they employ in furniſhing materials for conſtructing their waxen cells is their tongue, which is ſituate below the two teeth or fangs. When at work, the tongue is in perpetual motion, and its motions are extremely rapid: ſometimes it is more or leſs concave, and partly covered with a moiſt paſte or wax. By the different movements of its tongue the bee continues to ſupply freſh wax to the two teeth, which are employed in raiſing and faſhioning the walls of its cell, till they have acquired a ſufficient height. As ſoon as the moiſt paſte or wax dries, which it does almoſt inſtantaneouſly, it then aſſumes all the appearances and qualities of common wax. There is a ſtill ſtronger proof that wax is the reſult of an animal proceſs. When bees are removed into a new hive, and cloſely confined from the morning to the evening, if the hive chance to pleaſe them, in the courſe of the day ſeveral waxen cells will be formed, without the poſſibility of a ſingle bee having had acceſs to the fields. Beſides, the rude materials, or farina, carried into the hive, are of various colours. The farina of ſome plants employed by the bees is whitiſh: in others it is of a fine yellow colour; in others it is almoſt entirely red; and in others it is green. The combs conſtructed with theſe differently coloured materials are, however,

when newly made, of a pure white colour, which becomes more or leſs tarniſhed by age, the operation of the air, or by other accidental circumſtances. To bleach wax, therefore, requires only the art of extracting ſuch foreign bodies as may have inſinuated themſelves into its ſubſtance and changed its original colour.

Bees, from the nature of their conſtruction, require a warm habitation. They are likewiſe extremely ſolicitous to prevent inſects of any kind from getting admittance into their hives. To accompliſh both theſe purpoſes, when they take poſſeſſion of a new hive, they carefully examine every part of it, and, if they diſcover any ſmall holes or chinks, they immediately paſte them firmly up with a reſinous ſubſtance which differs conſiderably from wax. This ſubſtance was not unknown to the ancients: Pliny mentions it under the name of *propolis*, or bee-glue. Bees uſe this glue for rendering their hives more cloſe and perfect, in preference to wax, becauſe the former is more durable, and more powerfully reſiſts the viciſſitudes of weather than the latter. This glue is not, like wax, procured by an animal proceſs: the bees collect it from different trees, as poplars, birches, and willows. It is a complete production of Nature, and requires no addition or manufacture from the animals by which it is employed. After a bee has procured a quantity ſufficient to fill the cavities in its two hind thighs, it repairs to the hive. Two of its companions inſtantly draw out the glue, and apply it to fill up ſuch chinks, holes, or other deficiencies, as they find in their habitation. But this is not the only uſe to which bees apply the glue. They are extremely ſolicitous to remove ſuch inſects, or foreign bodies, as happen to get admiſſion into the hive. When ſo light as not to exceed their powers, they firſt kill the inſect with their ſtings, and then drag it out with their teeth. But it ſometimes happens that a ſnail creeps into the

hive. It is no ſooner perceived than it is attacked on all ſides and ſtung to death. The bees cannot carry out a burden of ſuch weight; and to prevent ſo large a body from diffuſing a diſagreeable odour through the hive, they immediately cover every part of it with glue, through which no effluvia can eſcape. When a ſnail with a ſhell gets entrance, to diſpoſe of it gives much leſs trouble to the bees. As ſoon as this kind of ſnail receives the firſt wound from a ſting, it naturally retires within its ſhell. In this caſe, the bees, inſtead of paſting it all over, are contented to glue all round the margin of the ſhell, which is ſufficient to render the animal immoveably fixed.

But glue, and the materials for making wax, are not the only ſubſtances theſe induſtrious animals have to collect. Beſide the whole winter, there are many days in ſummer in which the bees are prevented by the weather from going abroad in queſt of proviſions. They are, therefore, under the neceſſity of collecting, and amaſſing in cells deſtined for that purpoſe, large quantities of honey. This ſweet and balſamic liquor they extract, by means of their proboſcis or trunk, from the nectariferous glands of flowers. After collecting a few ſmall drops of honey, the animal with its proboſcis conveys them to its mouth and ſwallows them. From the gullet, it paſſes into the firſt ſtomach, which is more or leſs ſwelled in proportion to the quantity of honey it contains. When empty, it has the appearance of a fine white thread: but, when filled with honey, it aſſumes the figure of an oblong bladder, the membrane of which is ſo thin and tranſparent, that it allows the colour of the liquor it contains to be diſtinctly ſeen. The bees fly from one flower to another till they fill their firſt ſtomachs; then they return directly to the hive, and diſgorge in a cell the whole honey they have collected. It not unfrequently happens, however, that a bee, when on its way to the hive, is ac-

coſted by a hungry companion. How the one can communicate its neceſſity to the other, is perhaps impoſſible to diſcover. But the fact is certain, that, when, two bees meet in this ſituation, they mutually ſtop, and the one whoſe ſtomach is full of honey extends its trunk, opens its mouth, and, like ruminating animals, forces up the honey into that cavity. The hungry bee knows how to take advantage of this hoſpitable invitation, and with the point of its trunk, ſucks the honey from the other's mouth. When not ſtopped on the road, the bee proceeds to the hive, and in the ſame manner offers its honey to thoſe who are at work, as if it meant to prevent the neceſſity of quitting their labour in order to go in queſt of food. In bad weather, the bees feed upon the honey laid up in open cells; but they never touch theſe reſervoirs when their companions are enabled to ſupply them with freſh honey from the fields. But the mouths of thoſe cells which are deſtined for preſerving honey during winter, they always cover with a lid or thin plate of wax.

The honey-bees not only labour in common with aſtoniſhing aſſiduity and art, but their whole attention and affections ſeem to centre in the perſon of the queen or ſovereign of the hive. She is the baſis of their aſſociation and of all their operations. When ſhe dies by any accident, the whole community are inſtantly in diſorder. All their labours ceaſe; no new cells are conſtructed; neither honey nor wax are collected. Nothing but perfect anarchy prevails, till a new queen or female is obtained. The government or ſociety of bees is more of a monarchical than of a republican nature. All the members of the ſtate ſeem to reſpect and to be directed by a ſingle female. This fact affords a ſtrong inſtance of the force and wiſdom of Nature. The female alone is the mother of the whole hive, however numerous. Without her the ſpecies could not be continued. Nature, therefore, has endowed the reſt of the hive

with a wonderful affection to their common parent. For the reception of her eggs Nature impels them to conſtruct cells, and to lay up ſtores of proviſions for winter ſubſiſtence. Theſe operations proceed from pure inſtinctive impulſes. But every inſtinct neceſſarily ſuppoſes a degree of intellect, a principle to be acted upon, otherwiſe no impulſe could be felt, and, of courſe, no action nor mark of intelligence could poſſibly be produced.

Indeed, without ſome portion of intellect, or what is ſynonimous, of mental powers, how ſhould the different kinds of bees in the ſame hive be induced to perform ſo many different operations? While ſome are buſily employed at home in the conſtruction of cells, others are equally induſtrious in the fields collecting materials for carrying on the work. They are no ſooner relieved from their load by their companions and fellow-labourers in the hive, than they again repair to the fields, and, with perſevering induſtry, fly from flower to flower till they have amaſſed another load of materials, which they immediately tranſport to the hive. In this laborious office they perſiſt for many hours every day when the weather permits. Here every idea of mechanical impulſe is utterly excluded. That bees, as well as other animals, are actuated by motives, or impulſes, is willingly allowed. But theſe are not mechanical impulſes, as Buffon has abſurdly maintained: they are the wiſe and irreſiſtible impulſes of Nature upon their minds. If bees did not aſſociate, and mutually aſſiſt one another in their various operations, the ſpecies would ſoon be annihilated. Not one of them, it is probable, would ſurvive the firſt winter. But Nature, ever ſolicitous for the preſervation of her productions, has endowed their minds with an aſſociating principle, and with inſtincts which ſtimulate them to perform all thoſe wonderful operations that are neceſſary for the exiſtence of individuals, and the continuation of the ſpecies.

XXXIX. ON THE WONDERFUL INGENUITY OF WASPS.

The laws of life, why need I call to mind,
Obey'd by *inſects too* of ev'ry kind?
Of theſe, none uncontrol'd and lawleſs rove,
But to ſome deſtin'd end ſpontaneous move:
Led by that inſtinct Heav'n itſelf inſpires,
Or ſo much reaſon as their ſtate requires:
See all with ſkill acquire their daily food,
All uſe thoſe arms which Nature has beſtow'd;
Produce their tender progeny, and feed
With care parental, while that care they need;
In theſe lov'd offices completely bleſt,
No hopes beyond them, nor vain fears moleſt.

JENYNS.

THE wonders of Nature in the inſect tribes are not confined to what is obſervable in the operations of bees. The labours of waſps, though not beneficial to mankind, are not leſs ingenious and worthy of admiration.—Waſps, like the bees, aſſociate in great numbers, and conſtruct a common habitation with much dexterity and ſkill. There are many ſpecies of waſps, ſome of which unite into ſocieties, and others ſpend their lives in perfect ſolitude. But I ſhall confine my attention to the operations of the common aſſociating waſp, an inſect ſo well known, even to children, that it requires no deſcription. Though bees, as well as waſps, are armed with a ſting, yet the former may be regarded as a placid and harmleſs race. Bees are continually occupied with their own labours. Their chief care is to defend themſelves; and they never take nouriſhment at the expence of any other animal. Waſps, on the contrary, are ferocious animals, that live entirely on rapine and deſtruction. They kill and devour every inſect that is inferior to them in ſtrength. But,

though warlike and rapacious in their general manners, they are poliſhed and peaceable among themſelves. To their young they diſcover the greateſt tenderneſs and affection. For their protection and conveniency no labour is ſpared; and the habitations they conſtruct do honour to their patience, their addreſs, and ſagacity. Their architecture, like that of the honey-bee, is ſingular, and worthy of admiration; but the materials employed furniſh neither honey nor wax. Impelled by an inſtinctive love of poſterity, with great labour, ſkill, and aſſiduity, they conſtruct combs, which are compoſed of hexagonal or ſix-ſided cells. Though theſe cells are not made of wax, they are equally proper for the reception of eggs, and for affording convenient habitations to the worms which proceed from them, till their tranſformation into waſps.

In general, the cells of the waſps are formed of a kind of paper, which, with great dexterity, is fabricated by the animals themſelves. The number of combs and cells in a waſp's neſt is always proportioned to the number of individuals aſſociated. Different ſpecies chooſe different ſituations for building their neſts. Some expoſe their habitations to all the injuries of the air; others prefer the trunks of decayed trees; and others, as the common kind, conceal their neſts under ground. The hole which leads to a waſp's neſt is about an inch in diameter. This hole is a kind of gallery mined by the waſps, is ſeldom in a ſtraight line, and varies in length from half a foot to two feet, according to the diſtance of the neſt from the ſurface of the ground. When expoſed to view, the whole neſt appears to be of a roundiſh form, and ſometimes above twelve inches in diameter. It is ſtrongly fortified all round with walls or layers of paper, the ſurface of which is rough and irregular. In theſe walls, or rather in this external covering, two holes are left for paſſages

to the combs. The waſps uniformly enter the neſt by one hole, and go out by the other, which prevents any confuſion or interruption to their common labours.

This ſubterraneous city, though ſmall, is extremely populous. Upon removing the external covering, we perceive that the whole interior part conſiſts of ſeveral ſtories or floors of combs, which are parallel to each other, and nearly in a horizontal poſition. Every ſtory is compoſed of a numerous aſſemblage of hexagonal cells, very regularly conſtructed with a matter reſembling aſh-coloured paper. Theſe cells contain neither wax nor honey, but are ſolely deſtined for containing the eggs, the worms which are hatched from them, the nymphs, and the young waſps till they are able to fly. Waſps neſts are not always compoſed of an equal number of combs. They ſometimes conſiſt of fifteen, and ſometimes of eleven only. The combs are of various diameters. The firſt, or uppermoſt, is often only two inches in diameter, while thoſe of the middle ſometimes exceed a foot; the loweſt are alſo much ſmaller than the middle ones. All theſe combs, ranged like ſo many parallel floors or ſtories above each other, afford lodging to prodigious numbers of inhabitants. Reaumur computed, from the number of cells in a given portion of comb, that, in a middle-ſized neſt, there were at leaſt 10,000 cells. This calculation gives an idea of the aſtoniſhing prolific powers of theſe inſects, and of the vaſt numbers of individuals produced in a ſingle ſeaſon from one neſt; for every cell ſerves as a lodging to no leſs than three generations. Hence a moderate-ſized neſt gives birth annually to 30,000 young waſps.

The different ſtories of combs are always about half an inch high, which leaves free paſſages to the waſps from one part of the neſt to another. Theſe intervals are ſo ſpacious, that, in proportion to the

bulk of the animals, they may be compared to great halls, or broad ſtreets. Each of the larger combs is ſupported by about fifty pillars, which at the ſame time, give ſolidity to the fabric, and greatly ornament the whole neſt. The ſmall combs are ſupported by the ſame ingenious contrivance. Theſe pillars are coarſe, and of a roundiſh form. Their baſes and capitals, however, are much larger in diameter than toward the middle. By the one end they are attached to the ſuperior comb, and by the other to the inferior. Thus, between two combs there is always a ſpecies of ruſtic colonade. The waſps begin at the top and build downward. The uppermoſt and ſmalleſt comb is firſt conſtructed. It is attached to the ſuperior part of the external covering. The ſecond comb is fixed to the bottom of the firſt; and, in this manner, the animals proceed till the whole operation is completed. The connecting pillars are compoſed of the ſame kind of paper as the reſt of the neſt. To allow the waſps entries into the void ſpaces, roads are left between the combs and the external covering.

Having given a general idea of this curious edifice, it is next natural to inquire how the waſps build, and how they employ themſelves in their abodes. But, as all theſe myſteries are performed under the earth, it required much induſtry and attention to diſcover them. By the ingenuity and perſeverance of Reaumur, however, we are enabled to explain ſome parts of their internal economy and manners. This indefatigable naturaliſt contrived to make waſps, like the honey-bees, lodge and work in glaſs-hives. In this operation he was greatly aſſiſted by the ardent affection which theſe animals have for their offſpring; for he found, that, though the neſt was cut in different directions, and though it was expoſed to the light, the waſps never deſerted it, nor relaxed in their attention to their young.

When placed in a glaſs-hive, they are perfectly peaceable, and never attack the obſerver, if he calmly contemplates their operations; for they do not ſting, unleſs they are irritated.

Immediately after a waſp's neſt has been tranſported from its natural ſituation, and covered with a glaſs-hive, the firſt operation of the inſects is to repair the injuries it has ſuffered. With wonderful activity they carry off all the earth and foreign bodies that may have accidentally been conveyed into the hive. Some of them are occupied in fixing the neſt to the top and ſides of the hive by pillars of paper ſimilar to thoſe which ſupport the different ſtories or rows of combs; others repair the breaches it has ſuſtained; and others fortify it, by augmenting conſiderably the thickneſs of its external cover. This external envelope is an operation peculiar to waſps. Its conſtruction requires great labour; for it frequently exceeds an inch and a half in thickneſs, and is compoſed of a number of layers as thin as paper, between each of which there is a void ſpace. This cover is a kind of box for incloſing the combs, and defending them from the rain which occaſionally penetrates the earth. For this purpoſe it is admirably adapted. If it were one ſolid maſs, the contact of water would penetrate the whole, and reach the combs. But, to prevent this fatal effect, the animals leave conſiderable vacuities between each vaulted layer, which are generally fifteen or ſixteen in number. By this ingenious piece of architecture, one or two layers may be moiſtened with water, while the others are not in the leaſt affected.

The materials employed by waſps in the conſtruction of their neſts are very different from thoſe made uſe of by bees. Inſtead of collecting the farina of flowers, and digeſting it into wax, the waſps gnaw with their two fangs, which are ſtrong and ſerrated, ſmall fibres of wood from the faſhes of windows, the

poſts of eſpaliers, garden-doors, &c. but never attempt growing or green timber. Theſe fibres, although very ſlender, are often a twelfth part of an inch long. After cutting a certain number of them, the animals collect them into minute bundles, tranſport them to their neſt, and, by means of a glutinous ſubſtance furniſhed from their own bodies, form them into a moiſt and ductile paſte. Of this ſubſtance, or *papier maché*, they conſtruct the external cover, the partitions of the neſt, the hexagonal cells, and the ſolid columns which ſupport the ſeveral layers or ſtories of combs.

The conſtructing of the neſt occupies a comparatively ſmall number of labourers. The others are differently employed. Here it is neceſſary to remark, that the republics of waſps, like thoſe of bees, conſiſt of three kinds of flies; males, females, and neuters. Like the bees, alſo, the number of neuters far ſurpaſſes that of both males and females. The greateſt quantity of labour is devolved upon the neuters; but they are not, like the neuter bees, the only workers; for there is no part of their different operations which the females, at certain times, do not execute. Neither do the males, though their induſtry is not comparable to that of the neuters, remain entirely idle. They are often occupied in the interior part of the neſt. The greateſt part of the labour, however, is performed by the neuters. They build the neſt, feed the males, the females, and even the young. But, while the neuters are employed in theſe different operations, the others are abroad in hunting parties. Some attack with intrepidity live inſects, which they ſometimes carry entire to the neſt; but they generally tranſport the abdomen or belly only: others pillage butchers ſtalls, from which they often arrive with a piece of meat larger than the half of their own bodies: others reſort to gardens, and ſuck the juices of fruits. When

they return to the neſt, they diſtribute a part of their plunder to the females, to the males, and even to ſuch neuters as have been uſefully occupied at home. As ſoon as a neuter enters the neſt, it is ſurrounded by ſeveral waſps, to each of whom it freely gives a portion of the food it has brought. Thoſe who have not been hunting for prey, but have been ſucking the juices of fruits, though they ſeem to return empty, fail not to regale their companions; for, after their arrival, they ſtation themſelves upon the upper part of the neſt, and diſcharge from their mouths two or three drops of a clear liquid, which are immediately ſwallowed by the domeſtics.

The neuter waſps, though the moſt laborious, are the ſmalleſt; but they are extremely active and vivacious. The females are much larger, heavier, and ſlower in their motions. The males are of an intermediate ſize between that of the females and neuters. From theſe differences in ſize, it is eaſy to diſtinguiſh the different kinds of thoſe waſps which build their neſts below the ground. In the hive of the honey-bee, the number of females is always extremely ſmall; but in a waſp's neſt, there are often more than three hundred females. During the months of June, July, and Auguſt, they remain conſtantly in the neſt; and are never ſeen abroad except in the beginning of ſpring, and in the months of September and October. During the ſummer, they are totally occupied in laying their eggs and feeding their young. In this laſt operation, they are aſſiſted by the other waſps; for the females alone, though numerous, would be inſufficient for the laborious taſk. A waſp's neſt, when completed, ſometimes conſiſts of ſixteen thouſand cells, each of which contains an egg, a worm, or a nymph. The eggs are white, tranſparent, of an oblong figure, and differ in ſize, according to the kind of waſps which are to proceed from them. Some of them are no larger

than the head of a ſmall pin. They are ſo firmly glued to the bottoms of the cells, that it is with difficulty they can be detached without breaking. Eight days after the eggs are depoſited in the cells, the worms are hatched, and are conſiderably larger than the eggs which gave birth to them. Theſe worms demand the principal cares of the waſps that continue always in the neſt. They feed them, as birds feed their young, by giving them, from time to time, a mouthful of food. It is aſtoniſhing to ſee with what induſtry and rapidity a female runs along the cells of a comb, and diſtributes to each worm a portion of nutriment. In proportion to the ages and conditions of the worms, they are fed with ſolid food, ſuch as the bellies of inſects, or with a liquid ſubſtance diſgorged by the mother. When a worm is ſo large as to occupy its whole cell, it is then ready to be metamorphoſed into a nymph. It then refuſes all nouriſhment, and ceaſes to have any connection with the waſps in the neſt. It ſhuts up the mouth of its cell with a fine ſilken cover, in the ſame manner as the ſilkworm and other caterpillars ſpin their cods. This operation is completed in three or four hours, and the animal remains in the nymph ſtate nine or ten days, when, with its teeth, it deſtroys the external cover of the cell, and comes forth in the form of a winged inſect. In a ſhort time, the waſps newly transformed receive the food brought into the neſt by the foragers in the fields. What is ſtill more curious, in the courſe of the firſt day after their transformation, the young waſps have been obſerved going to the fields, bringing in proviſions, and diſtributing them to the worms in the cells. A cell is no ſooner abandoned by a young waſp, than it is cleaned, trimmed, and repaired by an old one, and rendered, in every reſpect, proper for the reception of another egg.

As waſps of different ſexes differ greatly in ſize,

they know how to conſtruct cells proportioned to the dimenſions of the fly that is to proceed from the egg which the female depoſits in them. The neuters are ſix times ſmaller than the females, and their cells are built nearly in the ſame proportion. Cells are not only adapted for the reception of neuters, males, and females, but it is remarkable that the cells of the neuters are never intermixed with thoſe of the males or females. A comb is entirely occupied with ſmall cells fitted for the reception of neuter worms. But male and female cells are often found in the ſame comb. The males and females are of equal length, and, of courſe, require cells of an equal depth. But the cells of the males are narrower than thoſe of the females, becauſe the bodies of the former are never ſo thick as thoſe of the latter.

This wonderful aſſemblage of combs, of the pillars which ſupport them, and of the external envelope, is an edifice which requires ſeveral months labour, and ſerves the animals one year only. This habitation, ſo populous in ſummer, is almoſt deſerted in winter, and abandoned entirely in ſpring; for, in this laſt ſeaſon, not a ſingle waſp is to be found in a neſt of the preceding year. It is worthy of remark, that the firſt combs of a neſt are always accommodated for the reception of the neuter or working waſps. The city, of which the foundation has juſt been laid, requires a number of workers. The neuter or working waſps are accordingly firſt produced. A cell is no ſooner half completed than an egg of a neuter is depoſited in it by the female. Of fourteen or fifteen combs incloſed in a common cover, the laſt four only are deſtined for the reception of males and females. Hence it uniformly happens, that, before the males and females are capable of taking flight, every waſp's neſt is peopled with ſeveral thouſand neuters or workers. But the neuters, that are firſt produced, are likewiſe the firſt that pe-

riſh; for not one of them ſurvives the termination even of a mild winter.

The female waſps are ſtronger, and ſupport the rigours of winter better than the males or neuters. Before the end of winter, however, ſeveral hundred females die, and not above ten or a dozen in each neſt ſurvive that ſeaſon. Theſe few females are deſtined for the continuation of the ſpecies. Each of them becomes the founder of a new republic. When a queen-bee departs from a hive in order to eſtabliſh a new one, ſhe is always accompanied by ſeveral thouſand induſtrious labourers, ready to perform every neceſſary operation. But the female waſp has not the aid of a ſingle labourer; for all the neuters are dead before the beginning of ſpring. The female alone lays the foundation of a new republic. She either finds or digs a hole under the earth, builds cells for the reception of her eggs, and feeds the worms which proceed from them. Whenever any of theſe neuter worms are transformed into flies, they immediately aſſiſt their parent in augmenting the number of cells and combs, and in feeding the young worms, which are daily hatching from the eggs. In a word, this female waſp, which in ſpring was perfectly ſolitary, without any proper habitation, and had every operation to perform, has, in autumn, ſeveral thouſands of her offspring at her devotion, and is furniſhed with a magnificent palace, or rather city, to protect her from the injuries of the weather and from external enemies.

With regard to the male waſps, it is uncertain whether any of them ſurvive the winter. But, though not ſo indolent as the males of the honey-bee, they can be of little aſſiſtance to the female; for they never engage in any work of importance, ſuch as conſtructing cells, or fortifying the external cover of the neſt. They are never brought forth till toward the end of Auguſt; and their ſole occupation

ſeems to be that of keeping the neſt clean. They carry out every kind of filth, and the carcaſſes of ſuch of their companions as happen to die. In performing this operation, two of them often join, and when the load is too heavy, they cut off the head, and tranſport the dead animal at two times.

In the beginning of ſpring, when the female waſp has built her ſubterraneous habitation, which is ſoon to be peopled with thouſands of flies, ſhe has no occaſion for the males; becauſe, in the month of September or October, ſhe had been previouſly impregnated. The males and females are produced at the ſame time, and they are nearly equal in number. Like the male honey-bees, the male waſps are deſtitute of ſtings, but the females and neuters have ſtings.

XL. CONCLUDING CONSIDERATIONS ON THE WONDERFUL INGENUITY OF CERTAIN INSECTS.

Deum namque ire per omnes
Terraſque, tractuſque maris, cœlumque profundum.
VIRGIL.

For God the whole created maſs inſpires.
DRYDEN.

THE aſſociation and economy of Ants, merit no leſs attention than thoſe of bees and waſps. With wonderful induſtry and activity they collect materials for the conſtruction of their neſt. They unite in numbers, and aſſiſt each other in excavating the earth, and in tranſporting to their babitation bits of ſtraw, ſmall pieces of wood, and other ſubſtances of a ſimilar kind, which they employ in lining and ſupporting their ſubterraneous galleries. The form of their neſt or hill is ſomewhat conical, and, of courſe, the water, when it rains, runs eaſily off, without penetrating their abode. Under this hill there are many galleries or paſſages which communicate with each other, and reſemble the ſtreets of a ſmall city.

Ants not only aſſociate for the purpoſe of conſtructing a common habitation, but for cheriſhing and protecting their offspring. Every perſon muſt have often obſerved, when part of a neſt is ſuddenly expoſed, their extreme ſolicitude for the preſervation of their chryſaliſes, or nymphs, which often exceed the ſize of the animals themſelves. With amazing dexterity and quickneſs the ants tranſport their nymphs into the ſubterraneous galleries of the neſt, and place them beyond the reach of any common danger. The courage and fortitude with which they

defend their young is no leſs aſtoniſhing. The body of an ant was cut through the middle, and, after ſuffering this cruel treatment, ſo ſtrong was its parental affection, with its head, and one half of the body, it carried off eight or ten nymphs. They go to great diſtances in ſearch of proviſions. Their roads, which are often winding and involved, all terminate in the neſt.

The wiſdom and foreſight of ants have been celebrated from the remoteſt antiquity. It has been aſſerted and believed, for near three thouſand years, that they lay up magazines of proviſions for the winter, and that they even cut off the germ of the grain to prevent it from ſhooting. But the ancients were never famed for accurate reſearches into the nature and operations of inſects. Theſe ſuppoſed magazines could be of no uſe to the ants; for, like the marmots and dormice, they ſleep during the winter. A very moderate degree of cold is ſufficient to render them torpid. In fact, it is now well known that they amaſs no magazines of proviſions. The grains which, with ſo much induſtry and labour, they carry to their neſt, are not to be the food of the animals, but, like the bits of ſtraw and wood, are employed as materials in the conſtruction of their habitation.

Beſide the *aſſociating* inſects, whoſe operations I have deſcribed, there are ſeveral ſpecies of bees diſtinguiſhed by the appellation of *ſolitary*, becauſe they do not aſſociate to carry on any joint operations. Of this kind is the maſon-bee, ſo called becauſe it builds a habitation compoſed of ſand and mortar. The neſts of this bee are fixed to the walls of houſes, and, when finiſhed, have the appearance of irregular prominences ariſing from dirt or clay accidentally thrown againſt a wall or ſtone by the feet of horſes. Theſe prominences are not ſo remarkable as to attract attention; but, when the external coat is re-

moved, their ſtructure is diſcovered to be truly admirable. The interior part conſiſts of an aſſemblage of different cells, each of which affords a convenient lodgement to a white worm, pretty ſimilar to thoſe produced by the honey-bee. Here they remain till they have undergone all their metamorphoſes. In conſtructing this neſt, which is a work of great labour and dexterity, the female is the ſole operator. She receives no aſſiſtance from the male. The manner in which the female maſon-bees build their neſts is the moſt curious branch of their hiſtory.

After chooſing a part of a wall on which ſhe is reſolved to fix a habitation for her future progeny, ſhe goes in queſt of proper materials. The neſt to be conſtructed muſt conſiſt of a ſpecies of mortar, of which ſand is the baſis. She knows, like human builders, that every kind of ſand is not equally proper for making good mortar. She goes, therefore, to a bed of ſand, and ſelects, grain by grain, the kind which is beſt to anſwer her purpoſe. With her teeth, which are as large and as ſtrong as thoſe of the honey-bee, ſhe examines and brings together ſeveral grains. But ſand alone will not make mortar. Recourſe muſt be had to a cement ſimilar to the ſlaked lime employed by maſons. Our bee is unacquainted with lime, but ſhe poſſeſſes an equivalent in her own body. From her mouth ſhe throws out a viſcid liquor, with which ſhe moiſtens the firſt grain pitched upon. To this grain ſhe cements a ſecond, which ſhe moiſtens in the ſame manner, and to the former two ſhe attaches a third, and ſo on, till ſhe has formed a maſs as large as the ſhot uſually employed to kill hares. This maſs ſhe carries off in her teeth to the place ſhe had choſen for erecting her neſt, and makes it the foundation of the firſt cell. In this manner ſhe labours inceſſantly till all the cells are completed, a work which is generally accompliſhed in five or ſix days.

All the cells are ſimilar, and nearly equal in dimenſions. Before they are covered their figure reſembles that of a thimble. She never begins to make a ſecond till the firſt be finiſhed. Each cell is about an inch high, and nearly half an inch in diameter. But the labour of building is not the only one this female bee has to undergo. When a cell has been raiſed to two thirds of its height, another occupation commences. She ſeems to know the quantity of food that will be neceſſary to nouriſh the young that is to proceed from the egg, from its excluſion till it acquires its full growth, and paſſes into the chryſalis ſtate. The food which is prepared for the ſupport of the young worm conſiſts of the farina or powder of flowers, diluted with honey, which forms a kind of pap. Before the cell is entirely finiſhed, the maſon-bee collects from the flowers, and depoſits in the cell, a large quantity of farina, and afterward diſgorges upon it as much honey as dilutes it, and forms it into a kind of paſte, or ſyrup. When this operation is performed, ſhe completes her cell, and, after depoſiting an egg in it, covers the mouth of it with the ſame mortar ſhe uſes in building her neſt. The egg is now incloſed on all ſides in a walled habitation hermetically ſealed. A ſmall quantity of air, however, gets admiſſion to the worm, otherwiſe it could not exiſt. Reaumur diſcovered that air actually penetrated through this ſeemingly compact maſon-work.

As ſoon as the firſt cell is completed, the maſon-bee lays the foundation of another. In the ſame neſt ſhe often conſtructs ſeven or eight cells, and ſometimes only three or four. She places them near each other, but not in any regular order. This induſtrious animal, after all her cells are conſtructed, filled with proviſions, and ſealed, covers the whole with an envelope of the ſame mortar, which, when dry is as hard as a ſtone. The neſt now is com-

monly of an oblong or roundiſh figure, and the external cover is compoſed of coarſer ſand than that of the cells. As the neſts are almoſt as durable as the walls on which they are placed, they are often, in the following ſeaſon, occupied and repaired by a ſtranger bee. Though incloſed with two hard walls, when the fly emerges from the chryſalis ſtate, it firſt gnaws with its teeth a paſſage through the wall that ſealed up the mouth of its cell; afterward, with the ſame inſtruments, it pierces the ſtill ſtronger and more compact cover which inveſts the whole neſt; at laſt it eſcapes into the open air, and, if a female, in a ſhort time, conſtructs a neſt of the ſame kind with that which the mother had made. To all theſe facts, Du Hamel, Reaumur, and many other naturaliſts of credit and reputation, have been repeatedly eyewitneſſes.

From the hardneſs of the materials with which the maſon-bee conſtructs her neſt, from the induſtry and dexterity ſhe employs to protect her progeny from enemies of every kind, we may naturally imagine that the young worms were in perfect ſafety, and that their caſtle was impregnable. But, notwithſtanding all theſe favorable precautions, the young of the maſon-bee are often devoured by the inſtinctive dexterity of certain ſpecies of four-winged inſects, diſtinguiſhed by the name of ichneumon flies. Theſe flies, when the maſon-bee has nearly completed a cell, and filled it with proviſions, depoſit their own eggs in her cell. After the eggs of the inchneumon flies are hatched, their worms devour not only the proviſions laid up by the maſon-bee, but even her progeny which ſhe had laboured ſo hard, and with ſo much art and ingenuity, to protect. But the maſon-bee has an enemy ſtill more formidable. A certain fly employs the ſame ſtratagem of inſinuating an egg into one of her cells before it is completed. From this egg proceeds a ſtrong and

rapacious worm, armed with prodigious fangs. The devaſtations of this worm are not confined to one cell. He often pierces through each cell in the neſt, and ſucceſſively devours both the maſon-worms, and the proviſions ſo anxiouſly laid up for their ſupport by the mother. This ſtranger worm is afterward transformed into a beetle, which is enabled to pierce the neſt, and to make its eſcape.

The operations of another ſpecies of ſolitary bees, called wood-piercers, likewiſe merit attention. Theſe bees are larger than the queens of the honey-bee. Their bodies are ſmooth, except the ſides, which are covered with hair. In the ſpring, they frequent gardens, and ſearch for rotten, or at leaſt dead wood, in order to make an habitation for their young. When a female of this ſpecies (for ſhe receives no aſſiſtance from the male) has ſelected a piece of wood or a decayed tree, ſhe commences her labour by making a hole in it, which is generally directed toward the axis of the tree. When ſhe has advanced about half an inch, ſhe alters the direction of the hole, and conducts it nearly parallel to the axis of the wood. The ſize of her body requires that this hole ſhould have a conſiderable diameter. It is often ſo large as to admit the finger of a man, and it ſometimes extends from twelve to fifteen inches in length. If the thickneſs of the wood permits, ſhe makes three or four of theſe long holes in its interior part. Reaumur found three of theſe parallel holes in an old eſpalier poſt. Their diameters exceeded half an inch. This labour, for a ſingle bee, is prodigious; but, in executing it, ſhe conſumes weeks, and even months.

Around the foot of a poſt or piece of wood where one of theſe bees is working, little heaps of timber-duſt are always found lying on the ground. Theſe heaps daily increaſe in magnitude, and the particles of duſt are as large as thoſe produced by a hand-ſaw.

The two teeth with which the animal is provided are the only inſtruments ſhe employs in making ſuch conſiderable perforations. Each tooth conſiſts of a ſolid piece of ſhell, which in ſhape reſembles an auger. It is convex above, concave below; and terminates in a ſharp but ſtrong point.

Theſe long holes are deſigned for lodgings to the worms that are to proceed from the eggs which the bee is ſoon to depoſit in them. But after the holes are finiſhed, her labour is by no means at an end. The eggs muſt not be mingled, or piled above each other. Every ſeparate worm muſt have a diſtinct apartment, without any communication with the others. Each long hole or tube, accordingly, is only the outer walls of a houſe which is to conſiſt of many chambers ranged one above another. A hole of about twelve inches in length ſhe divides into ten or twelve ſeparate apartments, each of which is about an inch high. The roof of the loweſt room is the floor of the ſecond, and ſo on to the uppermoſt. Each floor is about the thickneſs of a French crown. The floors or diviſions are compoſed of particles of wood cemented together by a glutinous ſubſtance from the animal's mouth. In making a floor, ſhe commences with gluing an annular plate of wood-duſt round the internal circumference of the cavity. To this plate ſhe attaches a ſecond, to the ſecond a third, and to the third a fourth, till the whole floor is completed. The undermoſt cell requires only a roof, and this roof is a floor to the ſecond, &c.

I have hitherto deſcribed the wonderful aſſiduity of this animal in conſtructing her cells. But this operation, though great, and ſeemingly ſuperior to the powers of a creature ſo ſmall, is not her only labour. Before roofing in the firſt cell, ſhe fills it with a paſte or pap, compoſed of the farina of flowers moiſtened with honey. The quantity of paſte is equal to the dimenſions of the cell; and into

this paſte, which is to nouriſh the future worm, ſhe depoſits an egg. Immediately after this operation, ſhe begins to form a roof, which not only incloſes the firſt cell, but ſerves as a floor to the ſecond. The ſecond cell ſhe likewiſe fills with paſte, depoſits an egg, and then covers the whole with another roof. In this manner ſhe proceeds, till the whole tube is divided into ſeparate cells, when the buſineſs of this laborious bee is finiſhed, and ſhe takes no more charge of her future progeny. The attention and ſolicitude beſtowed by many other animals, in rearing their young, are exerted after birth; but in the wood-piercing bee, as well as in many other inſects, this inſtinctive attachment is reverſed. All her cares and labours are exerted before ſhe either ſees her offſpring, or knows that they are to exiſt. But, after the deſcription that has been given of her amazing operations, ſhe will not be conſidered as an unnatural mother. With aſtoniſhing induſtry and perſeverance, ſhe not only furniſhes her young with ſafe and convenient lodgings, but lays up for them ſtores of proviſions ſufficient to ſupport them till their final metamorphoſis into flies, when the new females perform the ſame almoſt incredible operations for the protection and ſuſtenance of their own offſpring. When the young worm is hatched, it has ſcarcely ſufficient ſpace to turn itſelf in the cell, which is almoſt entirely filled with the pappy ſubſtance formerly mentioned. But, as this ſubſtance is gradually devoured by the worm, the ſpace in the cell neceſſarily enlarges in proportion to the growth and magnitude of the animal.

In a range of cells, the worms are of different ages, and, of courſe, of different ſizes. Thoſe in the lower cells are older than thoſe in the ſuperior; becauſe, after the bee has filled with paſte and incloſed its firſt cell, a conſiderable time is requiſite to collect proviſions, and to form partitions for every

ſucceſſive and ſuperior cell. The former, therefore, muſt be transformed into nymphs and flies before the latter. Theſe circumſtances are apparently foreſeen by the common mother; for, if the undermoſt worm, which is oldeſt, and ſooneſt transformed, were to force its way upward, which it could eaſily do, it would not only diſturb, but infallibly deſtroy all thoſe lodged in the ſuperior cells. But nature has wiſely prevented this devaſtation; for the head of the nymph, and conſequently of the fly, is always placed in a downward direction. Its firſt inſtinctive movements muſt, therefore, be in the ſame direction. That the young flies may eſcape from their reſpective cells, the mother digs a hole at the bottom of the long tube, which makes a communication with the undermoſt cell and the open air. Sometimes a ſimilar paſſage is made near the middle of the tube. By this contrivance, as all the flies inſtinctively endeavour to cut their way downward, they find an eaſy and convenient paſſage; for they have only to pierce the floor of their cells, which they readily perform with their teeth.

Another ſmall ſpecies of ſolitary bees dig holes in the earth to make a convenient habitation for their young. Their neſts are compoſed of cylindrical cells fixed to one another, and each of them, in figure reſembles a thimble. Their bottom, of courſe, is convex and rounded. The bottom of the ſecond is inſerted into the entry of the firſt; and the entry of the ſecond receives the bottom of the third. Sometimes only two of theſe cells are joined together; and, at other times, we find three or four, which form a kind of cylinder. This cylinder is compoſed of alternate bands of two different colours: thoſe of the narroweſt, at the juncture of two cells, are white, and thoſe of the broadeſt are of a reddiſh brown. The cells conſiſt of a number of fine membranes, formed of a glutinous and tranſparent ſub-

ſtance from the animal's mouth. The bee fills each cell with the farina of flowers diluted with honey, and in this paſte ſhe depoſits an egg. She then covers the cell, by gluing to its mouth a fine cellular ſubſtance taken from the leaves of ſome plant; and in this manner ſhe proceeds till her cylindrical neſt is completed. The worms which are hatched from the eggs feed upon the paſte, ſo carefully laid up for them by the mother, till they are transformed into flies ſimilar to their parents.

Among waſps, as well as bees, there are ſolitary ſpecies, which carry on no joint operations. Theſe ſolitary waſps are not leſs ingenious in conſtructing proper habitations for their young, nor leſs provident in laying up for them a ſtore of nouriſhment ſufficient to ſupport them till they are transformed into flies, or have become perfect animals.

I ſhall conclude this paper with obſerving, that ſome of the ancient philoſophers, and, in particular, Pythagoras and Plato, were ſo ſtruck by the wonderful ingenuity diſplayed in the operation of bees, that they thought them endued, not merely with inſtinct, but with ſomething of celeſtial intellect. To this idea Virgil thus alludes:

His quidam ſignis, atque hæc exempla ſecuti,
Eſſe apibus partem divinæ mentis, et hauſtus
Æthereos dixere.

Induc'd by ſuch examples, ſome have taught
That bees have portions of ethereal thought;
Endued with particles of heav'nly fires. DRYDEN.

END OF THE FIRST VOLUME.

M. Brown, Printer, St. John's-ſquare.


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